Surgery of Repair

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PRINCIPLES, PROBLEMS, PROCEDURES

JOHN F. PICK, S.B., M.M., M.D., F.I.C.S.

Clinical Assistant Professor of Surgery, University of Illinois Medical School, Member, The American Board of Plastic Surgery, Consulting Plastic Surgeon Illinois State Penitentiaries Formerly Chief Plastic Surgeon, Northington General Hospital, Fourth Service Command, A.U.S., Plastic Surgeon, Shriner's Hospital for Crippled Children, Chicago

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TO

MARGUERITE

my wife

and

to

PROFESSOR F. BURIAN

(Prague)

my preceptor

Preface

> It is a foolish thing to make a long prologue, and to be short in the story itself
>
> *2 Maccabees 2:32*

This book is intended for those who, realizing the important place which plastic surgery has attained in the prosecution of modern surgical therapeusis, are desirous of applying more understandingly its principles, practices and motives in their daily work. To the expert it may prove, it is hoped, to be a source for better over-all presentation of the vast field of plastic surgery to his aides and students.

Of all surgical specialties, plastic surgery is the least standardized, most rife with unsettled problems and fertile with procedures difficult of general application. This is only inspiration to research. To stimulate individual thinking, where two or more propositions are offered by authorities in the solution of a problem, a certain amount of discussion is risked—primarily for the intellectual guidance of the student, and always with the aim of emphasizing the weight and the importance of surgical principles in the evaluation of problems. In this, any text on plastic surgery must deviate somewhat from the time-honored ritualism of the general surgical text.

The book is divided into three sections for practical as well as pedagogic reasons. Language, problems, methods of approach, preoperative management, procedures and postoperative care in plastic surgery differ so materially in details from those of general surgery, that it seems pertinent to common understanding that they be presented in a manner at once understandable to the neophyte, as well as practical in application with the expert surgeon.

Section One, on "Principles," is written with the purpose of injecting a pedagogic pattern into the basic approaches to plastic surgery. It is very difficult to overemphasize the value and importance of principles. For that reason certain ones are rediscussed in more than one chapter. Repetition, like the summation of stimuli, bears fruit in teaching.

Section Two on "Problems in Plastic Surgery" is deemed outstandingly necessary for two reasons. The subjects treated therein are either the basic differentials of concept and practice between reconstructive and excisional surgery or they are in a state of flux and incompleteness because of the relative newness of the specialty. They remain, therefore, fundamental problems in surgery and should be so presented to the student in the hope of stimulating research in, and appreciation of, the still "unfinished business" of surgery. The latter, from a pedagogic standpoint, is too frequently denied the student. He is thus led to believe that the acquisition of an M.D. degree, by some strange trick of fate, makes him the fortuitous possessor of the last answer to the mysteries of man's bodily misfortunes and their ablation by the simple process of separating the pathologic from the healthy remains—via the scalpel.

Section Three, on "Procedures," is intended to illustrate the application of the principles discussed in Section One, with a view of laying emphasis on such procedures as are fundamental and of greatest benefit to surgeons in general. It is also the purpose of this section to present to the student sufficient material to indicate adequately

the vast scope of general plastic surgery Yet, not all the highly technical procedures in this field are included, because they are ultimately of interest only to the expert in the specialty Again comparatively little space is given to such important facets in this work as the harelip, the cleft palate radical jaw surgery and the making of prostheses which are adequately covered in texts devoted entirely to these subjects

Much of the thinking feeling and mental processes employed by the expert have been formulated according to plan and reduced to common denominators The attempt at the reduction of the principles, the problems and the procedures in plastic surgery to a common denominator has necessitated redelineation and authorship of certain presentations not ordinarily clarified in texts on plastic surgery Chapter 3, Personality Types , Chapter 6, Physical Examination" (Particular Examination), Chapter 9, 'Diagnosis', Chapter 15, 'Original Repair , and Chapter 21, 'Surgical Geometrics" These and others have been authored in the humble hope of elucidating perspectives peculiar to this specialty, with the ultimate aim that the book may be of pedagogic assistance in the presentation of the subject of plastic surgery

It is thus that the intellectual possessions of some become the practical armamentaria of many, for the ultimate benefit of all

Consider that I laboured not for myself only,
but for all them that seek learning
Ecclesiasticus *33* 17

THE AUTHOR

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To the men of the profession who in preceding us have laid the foundation for and opened the door to knowledge, without which this book would have been impossible.

To the contemporary men of the profession whose labors and research, much of which is cited in this book, entitle them to major credit for this volume. I have earnestly tried to give full credit to all authors whose works are quoted or cited in any manner. If any error of omission was committed, it was unintentional and is regretted.

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The Author

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SECTION ONE

PRINCIPLES

1

History

The history of plastic surgery may be divided into four great epochs (1) the *oriental period* of reconstruction of missing parts as practiced by the Hindus (4000 B C) (2) the *Egyptian period* of esthetic correction of defacements deformities and defects (2000 B C) (3) the *occidental period* of about 200 B C as recorded by Celsus and Galen to about A D 1900 as influenced by the Italians Branca and Tagliacozzi the Frenchmen Roux (1780 1854) Reverdin (Thesis of 1869) Dupuytren (1778 1835) the Germans Dieffenbach (1792 1847) von Graefe (1768 1840) and (4) the *universal period* of general plastic surgery which might be dated from the period of World War I when the idea of the reconstruction of the human form became a practical concern of general interest

The probability is that the idea of reconstruction of tissue deformities and the correction of bodily defacements as well as the desire for the improvement of the defective human form is as old as our civilization

The Hindus of 4 000 years ago impressed by the public nuisance of many noseless and earless humans the result of punishment for moral disobedience (still practiced in the hinterland) attempted the correction of facial deformities and defects by some vague process of gluing tissues to the affected part Their success obviously must have been rather meager but the need for such surgery became recognized as a social advantage rather than a functional necessity or psychological problem

The Egyptians of about 2 000 years ago on the other hand actually practiced certain esthetic surgical procedures upon lips chin ears nose and the human breast Scant records are to be found of their surgery because it is said they were very jealous of their art and so for many centuries little of it was brought to the European continent

The occidental period of plastic surgery is dated by most historians as beginning with Celsus who lived in the first century after Christ He is the first one to have left any more or less reliable records of the practice in his time In his *De Re Medicina* he describes corrective procedures upon mutilated ears eyelids noses and breasts Galen who followed Celsus in the second century after Christ most definitely performed operations on the human form which we today refer to as esthetic procedures He described certain of these operations in some detail but does not anywhere mention Celsus although it is presumed that he undoubtedly must have known of the work of the latter

Historically such procedures were not only practiced sporadically and confined to a few men but could not withstand the test of time for the obvious reasons that there was no anesthesia asepsis or any of the modern armamentaria which make such surgery consistently reliable There was another formidable deterrent peculiar to the times which was the official lack of recognition of the surgeon The latter was considered a socially inferior individual and a sinner This in fact had great influence on the development of surgery in general for centuries to come Any deliberate violation of the human form was considered a mockery of God and was forbidden by the church No gentleman worthy of the name would therefore dare to become involved in

the open practice of any form of surgery least of all the surgery of form

The influence of social customs and prejudices upon progress are but a recurring theme felt to some degree in every age Dogmas of course not only affect surgery but life in general

Furthermore during the time of Celsus and Galen certain deformities and injuries particularly in the male were considered as signs of strength and distinction in man as a warrior The pride of the nineteenth century German in his saber scars and the Heidelberg cheek was only a projection of old beliefs

Woman even after the period of Celsus and Galen was still looked upon as merely the repository for the sperm of man and the outlet for his sex hunger This was a social heritage from ancient times when she for convenience sake was rated somewhat above the domesticated beast The element of beauty was a prerogative of the man as was evidenced later by developments in Greek art Consequently woman continued to serve the one important function of reproduction Two outstanding historical examples of this are the Venus de Willendorf and the Venus de Laussel (Figs 1 and 2)

As with all sculpings of women of the day the faces in both instances are deliberately hidden from view by stringy hair in the case of the Laussel relief and by contrasts in the Willendorf sculping because facial beauty was but secondary to woman s function as the incubator for man s progeny Her appeal resided not in her symmetry and proportions but rather in what we today might refer to as her misproportions Because these to the ancients spelled fertility they were accepted as the primary signs of feminine desirability if not the evidence of contemporary beauty Consequently both Venuses are represented with face almost completely hidden breasts hanging to the umbilicus enormous thighs (the cradle of love) huge buttocks which were considered indispensable to the whole scheme of things To emphasize her importance as the servant of man she was provided with large feet looked upon as evidence of the good tiller of the soil This she incidentally had to be in order to help guarantee the earthly necessities of life under conditions which probably were not too adequate at best

The rise of Christianity seemed to bring more dignity to the incident of being a woman The establishment of the thesis of original sin made secondary and exaggerated physical signs of sex and virility a rather undesirable possession in the eyes of the church This undoubtedly had much to do with or was at least partially responsible for woman s taking greater pride in her physical appearance and proportions The aim and the custom developed to approximate the symmetries and the proportions of the Virgin Mary

As a result the desirable woman became the virginlike woman and the virgin became the ideal woman The sculptor s counterpart of this type became Aphrodite Because certain rules of sculping and painting were also laid down by the church about this time which incidentally were entirely opposite to what had been the custom before woman became a more symmetric creature and the proportions of virginity were made the ideal of her physical being Hence the age of Venus de Milo (Fig 3)

As for man the church held and decreed that he should look less like Adam and more like Christ the symbol of spirit rather than of flesh So the warrior with his pride of scar and other evidences of brute strength and virility gave place to the tiller of the soil and the God fearing one

Parallel with this as late as the beginning of the thirteenth century Pope Innocent III declared that no priest deacon or any official member of the church must ever perform any surgical procedure since it was a violation of the human form and a mockery of God

Consequently Tagliacozzi Professor of

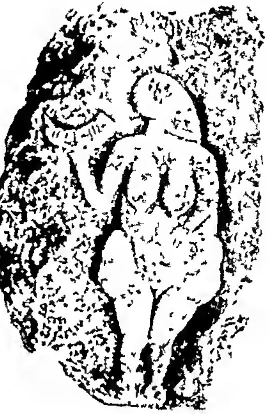

FIG 1 (*Left*) Venus de Willendorf The symbol of symmetry and beauty of a prehistoric era

FIG 2 (*Right*) Venus de Laussel Bas relief in limestone in Dordogne France 46 centimeters tall (*From l'Anthropologie*) The symbol of symmetry and beauty of ancient times Note emphasis on signs of pro-creative qualities Also de-emphasis of face

Anatomy and Surgery at the University of Bologna respected and admired as he was for his surgical skill by order of the church was exhumed and buried in strange ground All his books were ordered burned because his works were considered to be the meddling with God's handiwork Gaspar Tagliacozzi who lived between the years 1546 and 1599, is frequently referred to in medical literature as the Father of the Italian Renaissance of Plastic Surgery The profession was extremely slow in accepting the specialty of plastic surgery into the professional fold—only as late as 1941 in this country though somewhat earlier on the Continent It took three crusades to bring the Oriental and Egyptian knowledge of plastic surgery to the Continent and two world wars to fully awaken the profession to its meaning and usefulness

Not until about the middle of the nineteenth century were men like Von Graefe Dieffenbach Lisfranc and Carpue able to penetrate the prejudices and the darkness of the age and begin their individual but deliberate efforts at the application of surgery to the reconstruction of the defective human form This was followed by Reverdin's free transplantation of bits of skin and the foundation of the French school of Plastic Surgery Plastic surgery as such was nevertheless still confined to the minds and the hands of a very few surgeons

With the publication of Reverdin's thesis

FIG. 3 Vénus de Milo The basic pattern of the modern woman emphasizing grace, proportion, symmetry, and efficiency Note particular emphasis given to head, face, neck and breast

in 1869 on the transplantation of bits of epidermis, began an era in plastic surgery which is seeing its greatest development today, particularly in the United States, and mostly from Blair's "split graft"

Efforts at the free transplantation of skin continued with relatively partial, if not meager success until the beginning of World War I But from a historical standpoint Reverdin's attempts at the free transplantation of tissue completed a cycle of evolution dating back to the time of the Hindus who attempted to "glue" completely severed parts of the human form back into their original position. Coincident with the completion of that historic cycle, important collateral developments in the world of science in general began to make telling contributions to medicine, which after a few decades led to a new epoch in surgery.

Although it would be unfair to attempt to delineate the beginnings of the universal period in plastic surgery on a purely chronologic basis, in general it may be said that this period in the development of plastic surgery began shortly after the turn of the twentieth century It is the era in the development of plastic surgery where the free transplantation of tissues became more-or-less common knowledge

Notable contributions to this phase in the development of surgery were made particularly in this country by Blair, John Staige Davis, Ivy, J. B. Brown, Padgett and others (Fig. 4). In fact, the influence of the French school of plastic surgery beginning with Reverdin, has overshadowed all else that has gone before and much which has come to the fore since Paradoxically enough, the work in free-tissue transplantation as established by Reverdin (and popularized by Blair) has overshadowed certain other contributions to reconstructive surgery made by those who followed Reverdin. This in contrast might be referred to as the Physiological School of Plastic Surgery in France. The men after Reverdin, perceiving the shortcomings of the free transplantation of tissue, as well as the dangers of the so-called Italian flap, found greater advantage in the rotating flap, sometimes referred to as the French flap This, though the most physiologic concept of repair, gained little favor for a long time, undoubtedly because of all methods of reconstruction it is one of the most difficult to visualize and exercise It needs great

FIG 4 Pioneers of modern plastic surgery (*Top, left*) Vilray P Blair (*Top right*) John Staige Davis (*Bottom, left*) Ferris Smith (*Bottom, right*) Earl C Padgett

Fig 4 (*Continued*) (*Top, left*) Sir Harold Gillies (London) (*Top, right*) Sterling E Bunnell (*Bottom, left*) V H Kazanjian (*Bottom, right*) Professor Francis Burian (Prague)

surgical resourcefulness imagination and experience

Repair by contiguous and rotating flaps as advocated by the late French school of plastic surgeons of course has certain obvious technical and operative limitations Not all defects can be reconstructed by the use of contiguous tissues either because of the extent of the defect or the lack of the necessary amount of material collateral to the defect Neophysiologic methods such as free grafts and single pedicle flaps from distant parts of the body overtook later French medical thought and led to the easier and more universal acceptance of tissue transportation and transplantation The influence of the latter was particularly telling upon the development of plastic surgery in this country

It was only natural that the mechanical genius of America should sooner or later conquer what difficulties yet remained in the mobilization of free skin in more useful and practical amounts than had been done heretofore

Vilray P Blair devised the graft knife and the suction box With the invention of the Padgett dermatome the free graft a child of Reverdin s Greffe Epidermic became synonymous with plastic surgery In reality the dermatome may be said to have been a greater contribution to the armamentarium of general surgery than *plastic surgery itself for the free skin graft* is ultimately of incidental import to plastic surgery On the other hand it is indispensable as a particular form of surgical therapeusis The work of Blair Brown Padgett and others in connection with the popularization of the split skin graft will go down in medical history as an immense contribution to surgery in general

It took a world war to awaken the occidental world thoroughly to the possibilities of plastic surgery This applied particularly to the English speaking nations With the publication of his Plastic Surgery of the Face in 1920 Sir Harold Gillies an Englishman established an awareness on the part of English speaking surgeons of the importance of the surgical art It was during World War I that an essentially Anglo Saxon nucleus of plastic surgeons was formed on the European continent Sir Harold Gillies refers to this event in the preface of his text as follows

> Further with the arrival of American surgeons in 1918 under Colonel Vilray P Blair M R C U S A our wounded had call upon surgical skill from the whole Anglo Saxon race Each surgeon had the assistance of one or more colleagues from the New World to their mutual advantage In this connection the work of Valad er and Kazanjian in France has been of great service in the improvement of the treatment of jaw wounds I am indebted to the former for many photographs of the original conditions and to both for the stimulation of their work and for much kindly encouragement *
>
> Among many American colleagues Captain Ferris Smith has shown himself the most constructive critic the author has had the pleasure of knowing He was of great assistance in the preparation of the early proofs of this work

Besides those mentioned by Gillies others like John Staige Davis Sterling Bunnell and Robert Ivy brought back to this country the stimulus needed to awaken ultimately the American surgical faculty to the possibilities and the scope of this type of work With their relatively meager beginnings these men have definitely developed plastic surgery to a highly respected and useful level Their work will always remain a formidable part of the history of American medicine and surgery

The stimulus given by these men to surgeons in general is best expressed by W Arbuthnot Lane s words of introduction to Gillies text Among other things he states that

> It is not sufficiently recognized how readily the skill developed in th s branch of war surgery is directly applicable to the relief of dis

* Gillies H D Plast c Surgery of the Face *London Oxford 1920 p x*

to remove the disfigurements produced by destructive disease or violence or to remedy the deformities of congenital malformation The results obtained with such cases within the last half century are among the most satisfactory achievements of modern surgery *

On June 3 1946 John Staige Davis in his presidential address to the American Association of Plastic Surgeons Toronto Canada (Plastic and Reconstructive Surgery November 1946) brings the thoughts and the hopes of the past to fruition in the following words

In World War II *plastic surgery* as a general term was used for the first time in our medical military terminology instead of confining the subject to maxillofacial or facial plastic and oral surgery as had previously been done This on the surface seems a minor matter but the change was made only after the expenditure of much blood and sweat The field of military plastic surgery extends from the top of the head to the soles of the feet and its object is primarily the restoration of function and comfort and incidentally the improvement of appearance

When we entered World War I there was total ignorance of plastic surgery in the medical corps of the armed services of the U S but it must be said that even in civil hospitals and medical schools of that time 1917 the appreciation of this branch of surgery as a special subject was also totally lacking

To sum up in a few words I can say without reservation that the wounded service man in World War II who required plastic reconstruction has been better cared for in almost every way than he could have been in World War I

The superb results obtained in most of the armed service hospitals by the trained plastic surgeons and by the younger surgeons under their direction have been among the outstanding triumphs in the surgical annals of World War II †

* Buck Gurdon Contributions to Reparative Surgery *in Its Application to the Treatment of Deformities* Produced by Destructive Disease or Injury Congenital Defects from Arrest or Excess Development and Cicatricial Contractures from Burns New York D Appleton & Company 1876

† Davis J S Plastic Surgery *in* World War I and in World War II Plastic and Reconstructive Surgery *1 255 1946*

It is through the efforts and the accomplishments of such men as mentioned heretofore that plastic surgery has attained the dignity status and recognition of a major specialty in 1941 What the future will bring can only be surmised One thing is certain with the advent of new and more specific chemotherapeutic agents better knowledge of the genesis and the nature of neoplasm a greater awareness on the part of the public to preventive medicine in the future appendicitis cholecystitis respiratory conditions liver disease and a legion of others will become as rare as typhoid is at present To quote Morris Fishbein Only cardiovascular conditions will remain the most significant aspect of medical practice § To this I may add people will continue to meet with accidents and injuries as a result of more rapid and mechanical living if not the endless recurrence of war and a certain percentage will always be born congenitally defaced and deformed Hence the future of surgery is in the main one of form and function more so than disease The future holds great promise for the Surgery of Repair in contrast with the past which to a great extent has been the age of the Surgery of Despair

BIBLIOGRAPHY

Aufricht Gustave The development of plastic surgery in the United States Read before the Thirteenth Annual Meeting of the American Society of Plastic and Reconstructive Surgery New Orleans Louisiana October 16 1944

Aufricht Gustave The development of plastic *surgery in the United States* *Plast & Reconstruct Surg* 1 No 1 1946

Beck J C *Plastic and reconstructive surgery about the face and head—then and now* Ill M J Sept 1939

Blair V P The maxillofacial service of the American Army in the War J A M A 73 32 1919

Buck Gurdon Contributions to Reparative Surgery in Its Application to the Treatment of Deformities Produced by Destructive Disease or Injury Congenital Defects from Arrest or

§ Fishbein M L *Personal communication*

Excess Development and Cicatricial Contractures from Burns New York Appleton 1876
Buck Gurdon Tr M Soc N Y Albany 1866
Burian F Vznik a vyvoj Ustavu plasticke chirurgie v Praze Zvlastni otisk z casopisu Csl Nemocnice Tiskem J Snajdra v Kladne 1937
——— Plasticka Chirurgie V Ceskoslovensku Zvlastni otisk z casopisu Ceskoslovensko 1 c 5 1946
Carpenter G K Advances in bone graft surgery attributed to World War II Surg Gynec & Obst 84 No 4A 1947
Celsus Aurelius De Medicina etc 1748 ed 2 Accurate ravisa Basileae apud Joh Rudolf Thurneisen 1748
Churchill F D The American Surgeon A U S Surg Gynec & Obst 84 No 4A 1947
Chaue C Philosophie de la médecine communication a la Societe de pathologie comparee Seance du mardi 11 juin 1946
Coller F A and Farris J M The surgery of modern warfare Surg Gynec & Obst 72 15 1941
Cunha Felix The ebers papyrus Am J Surg 77 134 1949
Davis J S Plastic and reconstructive surgery J A M A 67 338 1916
——— Plastic Surgery Its Principles and Practice Philadelphia Blakiston 1919
——— Plastic surgery in World War I and in World War II Ann Surg 123 610 1946
——— The story of plastic surgery Ann Surg 113 641 1941
DeBakey M F Military surgery in World War II New England J Med 236 341 1947
Dorrance G M The Operative Story of Cleft Palate Philadelphia and London Saunders 1933
Editorial Traumatic surgery and the war of tomorrow Am J Surg (N S) 52 No 2 1941
——— The rapid growth of reconstructive surgery Am J Surg (N S) 43 No 2 1939
Ivy R H and Miller H A Plastic surgery 1939 Arch Otolaryng 32 159 1940
Jirasek Arnold Uvahy o Chirurgii a Chirurgovi Uvodni prednasky klinicke z let 1927 az 1936 Praha p 97 1937
Kirk N T Surgical care of the wounded in the United States Army Surgery 15 211 1944
Maliniac J W American society of plastic and reconstructive surgery—its beginning objectives and progress 1932 1947 Plast & Reconstruct Surg 2 No 6 1947
Mutter T D Am J M Sc 20 341 1837, Am J M Sc 22 61 1838 Am J M Sc (N S) 4 66 1842
——— Cases of Deformity from Burns by Plastic Surgery Philadelphia Merrihew & Thompson 1843
Orr H W The history of bone transplantation in general and orthopedic surgery Am J Surg (N S) 43 No 2 1939
Pancoast J A Discourse Commemorative of the late Prof T D Mutter M D LL D being the Introductory Lecture to the Course of Anatomy in the Jefferson Medical College of Philadelphia delivered Oct 14 1859
——— Am J M Sc (N S) 4 336 1842
Simonds J P A nineteenth century doctor and twentieth century medicine President s Address Dec 7 1937 Proc Inst Med Chicago 11 No 18 1937
Updegraff H L The fall and rise of plastic surgery Am J Surg (N S) 43 No 2 1939
Weintrob Morris Surgical lessons of World War II J Internat Coll Surgeons 12 50 1949

2

Physiologic Considerations

Modern surgery means physiologic surgery The physiologic perspective in plastic surgery poses three questions First what is the relationship of surgery to trauma? Second what is the effect of transplantation upon tissue biophysiology? Third what relationship does plastic surgery have to the integrity of the individual as a psychosomatic unit?

SURGERY AS TRAUMA

Surgery is trauma That unavoidable and incontrovertible fact should be more adequately stressed in our teachings Upon that principle must be based all surgical thinking and procedure (Fig 5)

The implications of trauma be it surgical or accidental are of great moment in plastic surgery because the very basis of the specialty is the correction of the untoward results of trauma The practice of utmost meticulousness and physiologic caution not always possible in other forms of surgery becomes the sine qua non of plastic surgery

Thoroughly meticulous procedure can only be practiced consistently in selected operations The major proportion of plastic surgery being both selective and of necessity technically controlled thus becomes the only logical form of surgery Through choice design and meticulousness it substitutes the results of minimal trauma for the consequences of major trauma which are always more telling and therefore less desirable Hence the plausibility of the correction of one kind of trauma by another that is the correction of accidental trauma by surgical trauma

The surgeon s disregard of the fact that surgery is trauma coupled with the lack of understanding of skin as an organ frequently leads to unphysiologic procedures with undesirable functional after effects Methods of dissection at times resemble a kind of design in laceration and the closure of operative wounds is not always much superior to ordinary basting Skin incisions are frequently executed as if they were a kind of nuisance hurdle to be negotiated with dispatch This is inconsistent with physiologic teaching and thinking

In the last analysis surgery is but a series and a succession of incisions and closures There is no physiologic premise which will substantiate the incising or the dissecting of one tissue with more consideration and kindness than another Unless this principle is fully understood all operating literally becomes traumatic surgery

The physiologic interdependency of one tissue upon another is of such an order that excessive trauma to one will unavoidably affect its neighbor If the incision through the skin is anything but a planned decisive and accurate sweep to a calculated depth it will prove to be nothing but a succession of cuts or jabs which will result in the destruction of not only the cells in the line of the blade but of actual masses of cells surrounding it These never can survive the ordeal of healing and will at best result in the accumulation of masses of fibrous tissue which will ultimately affect the integrity of all other contiguous tissues The masses of devitalized tissue the result of repeated attempts at cutting not only result in fibroses but contribute greatly to the post operative troubles of the wound including

Fig 5A Unavoidable surgical trauma (*Top*) Necessary and unavoidable dissection (surgical trauma) in enucleation of extensive tumor of right parotid (*Bottom left*) Healed compound fracture of left leg illustrating unavoidable excision necessary (*Bottom right*) Excision completed on bloc Note clean and precise skin edges and smooth dissection of deep tissues

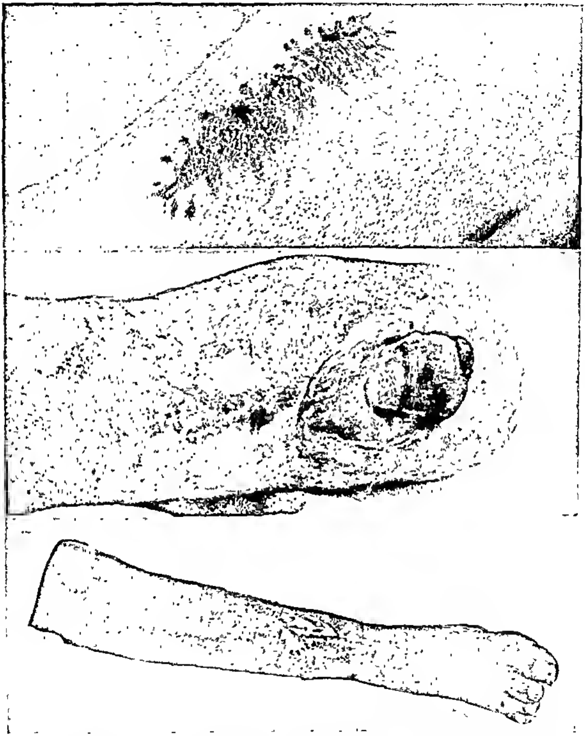

FIG. 5B. Superfluous surgical trauma (*Continued*). (*Top*) Typical hypertrophic scar due to tight sutures. (*Center*) Pressure sore (right heel) due to cast. (*Bottom*) Manipulative compound fracture (right leg) due to rough handling of simple fracture, resulting in skin perforation by proximal fragment. Condition as illustrated was of 18 months' duration; inexcusable trauma (see Plate 14).

central nervous system undergoes irreparable and irreversible disintegration The transplantation of such tissues from cadavers would seem to be a questionable procedure

For the same reason the direct transplantation of skin from cadavers (necrohomografts) after the lapse of about 24 hours can hardly be looked upon as a judicious physiologic act The transplantation of cartilage or bone on the other hand within a period of time when physiologic integrity is still present seems to be a more reasonable act These tissues being of a low metabolic order can subserve their basic function even if removed some days after clinical death providing such tissues are properly conserved after their removal Muscle tissue on the other hand because of its physiologic threshold does not lend itself to free transplantation as an autograft let alone as a homograft

The transplantation of entire joints from one individual to another (Lexer) with the idea of permanent results are only other attempts at tissue grafting without proper recognition and understanding of the physiologic principles which underlie such procedures Though many things may seem theoretically possible if they are unphysiologic they remain unreasonable and therefore surgically impractical Even if it were possible to transplant the head or the hide of animal to man it is difficult to see how the ultimate result could still remain human These are only a few of the physiologic indiscretions and surgical oddities which create more confusion in our thinking than progress in surgery

The disregard of basic biophysiologic principles when coupled with extensive surgical trauma though it may at times result in a certain degree of apparent clinical success nevertheless proves functionally inadequate because it is physiologically wanting Surgery being an evolutionary science as well as an art will always be guilty in a measure of a certain amount of neoscientific practice which in succeeding generations will cause a degree of amazement

Foremost among such contemporary practices for instance is the tendency toward extravagance in the use of skin grafts in conditions where the tissue cost is superfluous unnecessary or too high This applies particularly to the use of the so called epidermic and thin split grafts in all manner of conditions also to injudicious autografting in very extensive burns

An extensive burn is a physiologic disaster and a surgical tragedy Such an insult to the skin an important organ of the body results in far reaching and profound physiologic disturbance of the entire organisms economy In one s anxiety to help a badly burned patient if sheets of normal skin are taken from the unburned portion of the body one may be committing a physiologically regrettable act Insult is added to injury by further disruption of the function of the skin organ by surgical depletion of the normal skin This may lead to a degree of physiologic invalidism only later apparent when the patient begins to function actively as a unit If such a case is followed closely after operation—this I have had the opportunity to do during World War II—sooner or later following recovery from the burn the individual finds it difficult to compensate for the physiologic insult this is the result of surgical extravagance consequent upon mobilization of too much of the remaining healthy skin for the purpose of patching up a burned body Not long after becoming ambulatory such an individual will begin to complain of certain symptoms of indisposition heat flashes shortness of breath nocturia malaise gastro intestinal upsets and many other complaints at first vague but which may or may not get worse as the patient becomes more active and grows older This depends upon the severity of the surgical trauma as much as it does upon the extensiveness of the original burn Nevertheless these are signs of a general physiologic invalidism entirely consistent

genuity and surgical imagination but yields the most satisfactory functional and esthetic results (Fig 7)

The neophysiologic nature of the single wounds viz infection lymph stasis fibrosis venous stasis and scarring (Fig 8)

This later becomes clinically evident in the amount of subcutaneous fibrosis under

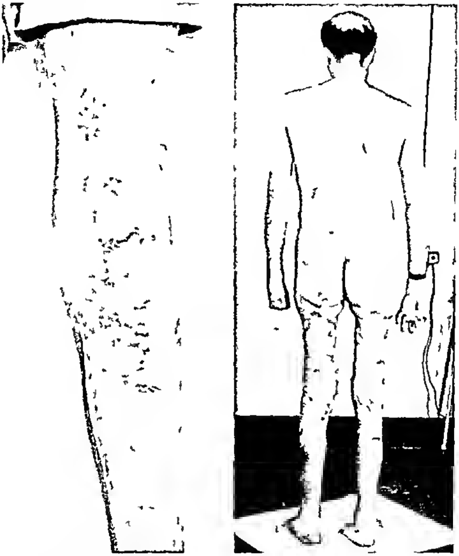

FIG 6A Clinical results with free grafts (*Left*) Bronzing of epidermic graft on medial surface of lower extremity as contrasted with thick split graft on upper lateral surface of extremity (*Right*) Degree of shrinkage of thin split grafts applied to lower extremities (4 months postoperatively)

pedicle flap is further assured by the fact that it is a result of "open" surgery The exposure of raw tissue, be it intentional or accidental, subjects that tissue to the same pathologic changes afflicting all open the graft which originated as an open flap The evidences are frequent puckering of the flap graft, the greater incidence of pigmentary changes in such grafts more protracted time of healing, greater frequency

Fig. 6B. Clinical results with free grafts (*Continued*). (*Left*) Results with "postage stamp" grafts of thick split variety applied on left leg. Contrast right leg which shows burn healed in part by scar epithelium (Fig. 6A, *left*). (*Right*) Thick split graft applied to gross injury calf of leg. Note timbre and smoothness of graft as compared with epidermic and thin split grafts. (*Bottom*) Advantages of full thickness graft in this case covering lateral side of nose and anterior facies of cheek replacing excised congenital hemangioma. Cheek reconstruction by cervical flap (see also Plate 15). Both done in one stage operation.

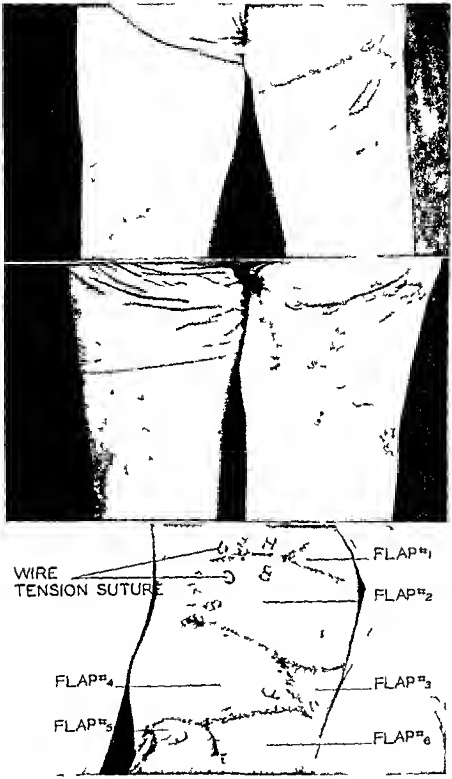

FIG 7 Results with French (contiguous) flaps (*Top*) Split grafted defect back of right thigh donor site back of left thigh The patient could not sit because of insufficient coverage of sciatic nerve (*Center*) After partial excision of split graft and replacement by French (contiguous) flap from lateral aspect of right thigh (*Bottom*) Final excision of all split grafted area and reconstruction via French flaps Flap 1 from trochanteric region Flaps 2 and 3 from lateral aspect of thigh Flap 4 from inner aspect of thigh rotated down and laterally Flaps 5 and 6 advanced from posterior aspect of thigh upwards

FIG 9 Author's "pin cushion" flap (closed surgery) a type of pillowed pedicle (*Top*) "Pin cushion" flap of left thigh Note reflection in mirror Donor area closed by split graft taken from lateral aspect of thigh (*Bottom*) Extent of donor site as well as size and mobility of "pin cushion" flap The distal one half of flap folded and sutured under proximal half Dark line and spot on flap due to methylene blue Rubber bands attached below knee source of traction applied to flap to prevent shrinkage (see Fig 74 *bottom left*) In 2 to 3 weeks flap is unfolded and ready for use

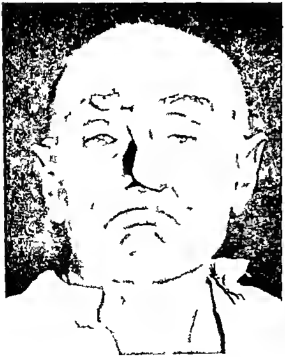

FIG 11A Types of invalids often overlooked by surgery (*Top left*) Tissue void due to hot coal from passing locomotive striking patient in open mouth Besides obvious external loss there was absence of anterior half of palate and major portion of septum (*Top right*) Defacement due to steel and gun powder tattoo the result of a war injury For one stage total grafting of the patient's face including eyelids see Chapter 22 and Plate 9 (*Bottom*) Tissue void due to syphilis consisting of total loss of septum left palate and premaxilla besides obvious external voids

the person If that surgery does not meet the physiologic and the psychological needs of the individual as well he will in some measure always remain a patient to some one If, on the other hand, surgery cannot or will not for one or another reason accept this perspective in the correction of the individual's defects he will in one way or another be relegated to the life of an invalid (Fig 11)

Surgical progress can only find its larger claim in its adequate orientation apropos the evolutionary and social metamorphosis of the individual As newer diseases and defects mount the podium of effective every day life and interfere with the individual's well being or social welfare they become sooner or later a challenge or test to surgical ingenuity and progress

The psychosomatic perspective that the patient is a functional unit as well as a social principle dictates both a greater physiologic consciousness and a psychological appreciation on the part of the surgeon in respect to the individual

BIBLIOGRAPHY

Auerbach E and Doljanski L Effect of cell growth activating tissue extracts parenterally applied on experimental skin wounds Proc Soc Exper Biol & Med 58 No 2 1945

Aufricht G Immediate transplantation on defects due to accident Report of Two Cases Arch Otolaryng 17 769 1933

Barnes R Bacsich P Wyburn G M and Kerr A S A study of the fate of nerve homografts in man Brit J Surg 34 No 133 1946

Baxter Hamilton The effect of penicillin and streptomycin applied locally on the take of skin grafts Plast & Reconstruct Surg 1 322 1946

Baxter Hamilton and Entin M A Experimental and clinical studies of reduced temperature in injury and repair in man—I Structure and potentialities of human skin in temperature control and in defense against thermal trauma Plast & Reconstruct Surg 2 No 6 1947

Baxter H Entin M A and More R H Experimental and chemical studies of reduced temperatures in injury and repair Plast & Reconstruct Surg 3 No 1 1948

Bergmann Ernst, and Krida Arthur Aseptic necrosis and bone drilling Arch Surg 44 81, 1942

Best, C H and Taylor N B Vasomotor Reflexes Physiological Basis of Medical Practice, Baltimore Williams & Wilkins 1945 p 238

——— Functional Morphological and Chemical Changes in Denervated Muscle Physiological Basis of Medical Practice Baltimore Williams & Wilkins 1945 p 866

Billig H E Muscle reinnervation J Internat Coll Surgeons 7 No 6 1944

Bloom David Cutaneous ulceration in organic central nervous disease Report of trophic ulcers in a case of postmeningitic myelitis and in a case of dermoid cyst of the spinal cord New York State J Med 47 No 22 1947

Bothe R T and Davenport H A Reaction of bone to metals Surg Gynec & Obst 74 231 1942

Brown David Survival of cortical bone after bone grafting Brit M J 1 389 1946

Brown J B and Byars L T Spontaneous and surgical covering of raw surfaces Journal Lancet 60 503 1940

Brown J B and McDowell F Epithelial healing and the transplantation of skin Ann Surg 115 1166 1942

——— Persistence of function of skin grafts through long periods of growth Surg Gynec & Obst 82 848 1941

Brown M H Grindlay J H and Craig W M The use of polythene film as a dural substitute, an experimental and clinical study Surg Gynec & Obst 86 No 6 1948

Burian F Quelques notes sur les transformations de l'autogreffe cartilagineuse Extrait de la Revue de Chirurgie Plastique n° 1 mai 1934

——— Fysiologicke Operovani Knihtiskarna Typus V Praze 1945

Butcher E O Fate and Activity of Autografts and Homografts of Skin in White Rats (Summary)

Campbell E Meirowsky A and Tompkins V Studies on the use of metals in surgery—Page II Ann Surg 116 No 5 1942

Chandy J The fate of preserved heterogeneous grafts of fascia when transplanted into living human tissue Surg Gynec & Obst 83 145 1946

Conway H Sweating function of transplanted skin Surg Gynec & Obst 69 756 1939

Cordier G et Demirleau J L'utilisation du plasma ou serum animal chez l'homme, Plasma ou serum universel detoxique Presse méd 54 833, 1946

Cowdry, E V Cooper Z and Smith W

ulcers J Internat Coll Surgeons 10 No 5 1947
Pollock L J Effect of extremes of environmental change in man Arch Neurol & Psychiat 49 421 1943
Rabinovici N The fate of skin homotransplants performed on previously x rayed rats Plast & Reconstruct Surg 2 No 5 1947
Randall W C *Quantitation and regional distribution* of sweat glands in man J Clin Investigation 25 761 1946
Roche M B and Jostes F A Ectopic bone deposits A *paraplegic complication* Am J Surg 75 No 4 1948
Rosen E Heterogeneous conjunctival transplantation Am J Ophth 29 No 2 1946
Searcy H B Carmichael E B and Wheelock M C Implant material The production of fibrous tissue around the fibers of cotton and other foreign material implanted subcutaneously *in rats* Southern M J 37 140 1944
Seddon H J Young J Z and Holmes W The histological condition of a nerve autograft in man Brit J Surg 29 378 1942
Shawan H K Principle of blood grouping applied to skin grafting Am J M Sc 157 503 1919
Steinberg B and Hufford V Development of bone marrow in adult animals Arch Path 43 117 1947
Straatsma C R Surgical technique helpful in obtaining fine scars Plast & Reconstruct Surg 2 No 1 1947
Tanner F H Some aspects of traumatic pathology Nebraska M J 32 69 1947
Thompson M B and Gellhorn E *Influence* of muscle pain on electrical resistance of the human skin Proc Soc Exper Biol & Med 58 No 2 1945
Vineberg A M Development of an anastomosis *between the coronary vessels and a transplanted* internal mammary artery Canad M A J 55 117 1946
Weir J G Modern physiologic concepts J A M A 134 No 7 1947
Weiskotten H G Histopathology of superficial burns J A M A Jan 25 1919 p 259
Wertheimer P D Aubigne R M and Dejardin L Reparation des Pertes de Substance Traumatiques des Troncs Nerveux des Membres Association francaise de Chirurgie XLIX[e] Congres francais de Chirurgie Paris 1946
Wilson H and Ridgon R H Capillary permeability and *inflammation in the skin of rabbits* Experimental studies following sectioning of the spinal cord Arch Surg 45 416 1942
Woolf A E M Tissue infiltration by cholesterol as a result of trauma Brit J Surg 29 327 1942
Yesipova I K Histology of a nerve graft four months after operation Am Rev Soviet Med 6 37 39 1946 (Nevropatologia i psikhiatriya 13 44 46 1944)
Young F The use of autogenous rib cartilage grafts to repair surface defects in dog joints Surgery 7 254 1940
——— *Experiences with tubed pedicle flaps* Surg Gynec & Obst 60 291 1935
——— Autotransplantation and homotransplantation of cartilage in the guinea pig Am J Path 2 111 1926

ates he finds it difficult to adapt himself to situations even though he may have tried The *second type of individual finds it impossible to adapt himself* and he seldom tries because he is basically maladjusted and a true psychoneurotic The former with proper and intelligent help can be rid of his neurosis whereas the latter will only find *some other form of complaint with* which to indulge his personality and plague the doctor

The exact psychiatric delineation of the various types and subtypes is not within the compass of this volume For purposes *of the plastic surgeon I have found it more* convenient in daily routine to divide the patients who present themselves for corrective plastic procedures into three categories the subjective type the objective type and the neutral type

PERSONALITY TYPES

The *subjective* type is the emotionally maladjusted or psychoneurotic person type whom it is well to recognize as soon as he enters the office He not infrequently carries a list of all the plastic surgeons in the city and seldom fails in seeing them The *objective* type is the rather well adjusted intelligent individual in whom a neurosis is the direct result of the difficulties precipitated by a disproportion deformity or congenital marking He is often referred to the plastic surgeon by the psychiatrist The *neutral* type is the completely adjusted intelligent individual who comes to seek relief from a deformity or defacement at the insistence of some member of the family but who personally is inclined to disregard the defect

The subdivision of cases which present themselves for corrective plastic procedures *into the foregoing categories* makes *for* simple practical and easy identification of the main personality types and has proved in my hands to be a quick and reliable diagnostic pattern without recourse to complicated psychiatric terminology

The diagnostic inventory of a patient should begin from the time he presents himself *in the office of the surgeon* One should carefully observe his general appearance behavior the manner of description of the complaint the exact reason why the patient is seeking surgery what he expects from the surgery behavior during the interview and examination and other such personal peculiarities as are indicated under the heading of type outlined under Subjective Objective and Neutral All such observations and findings should be recorded in the outline accompanying Chapter 5 *History Taking* This concise form has been devised and found to be a more adequate kind of office record than the type history generally used by surgeons

The Subjective Type

A patient who falls into the subjective category is one to guard against Corrective plastic procedures never should be done in such a case except upon advice of a competent psychiatrist If by some mistake or injudicious error such a patient is operated upon he will become a chronic office nuisance difficult to manage

The subjective type of patient is basically a psychoneurotic He is emotionally maladjusted and often not interested in helping himself His general appearance is frequently that of an overdressed yet soiled plethoric and overanxious individual His behavior is that of a frustrated fearful person who frequently exhibits tics and nervous twitchings of the face His complaint *and description of the lesion are almost invariably* exaggerated and out of proportion to what the surgeon can see for himself During the physical examination he is talkative nervous and interrogating His reasons for seeking surgery have for their background some frustration recent emotional experience or the desire to appeal to others His expectations from the surgery upon close questioning will prove to be of uncertain design and not infrequently they

logical kind Preoperatively he is co operative and dependable

In contrast with the subjective type he is far more nervous when placed upon the operating table He is usually much more sensitive to pain than the other and may even exaggerate his discomfort He must be more frequently reassured that everything is coming along as planned than is the case with the subjective type—the martyr to the cause

Postoperatively the objective type is co operative and reasonable He is almost invariably gratified and happy over whatever improvement has been attained Even though the results may not always be what the surgeon has hoped for this type of individual readily accepts the logical reasons for it The postoperative personality change is almost always of a positive kind with definite and early signs of better adjustment Improvement in intellectual acuity is not unusual

The eventual tissue results are more or less parallel with the gain in personality improvement The doctor patient relationship is uniformly good In the management of this type of patient the surgeon must maintain at all times a realistic sympathetic and honest attitude toward the patient s psychological problems Only thus will the most gratifying results be obtained from both the physical as well as the personality point of view

Every effort should be made to remedy the defacement lesion or deformity since these are obviously the essential cause of such an individual s unhappiness In this type of case plastic surgery often resolves the problem of mental hygiene more realistically and more quickly than psychiatry is able to do

The Neutral Type

The neutral type of patient is one who accepts his defacement or has compensated for it to the point of complete indifference The only reason why he ever appears in a plastic surgeon s office is that some member of his family, his employer or friend repeatedly insists that it would be better for his appearance or welfare if such a defect were removed When on the other hand this type of individual comes of his own volition requesting the removal of a defacement it is usually due to the fact that he has noticed a progressive enlargement of the defect or fears malignant change

He is a patient of good general appearance whose behavior is casual and bears all the signs of complete adjustment The defacement is described in a manner which is objective and true His behavior during examination on the operating table and postoperatively is no different from that of a patient who is being treated for a contrast ailment His expectations from the treatment are simple he asks only that it be a surgical success Such a patient more than any other type often enjoys considerable satisfaction from the correction of a defacement It is ultimately not unwise in this type of case to allow the patient to make the final decision as to when surgery is to be done If the defect on the other hand shows clinical or biopsy signs of malignant change such a patient should be so instructed and should be encouraged in the decision to submit to surgery He should also be informed that if evidence of actual malignancy is present more than one operation may be necessary to accomplish final reconstruction of the part

The importance of differentiating the various types of patients presenting themselves for corrective procedures ultimately lies in the fact that whereas in the neutral type one may add to the patient s physical well being and whereas in the objective type one may be directly instrumental in contributing to the mental hygiene and positive improvement in personality in the so called subjective type one may precipitate a personality casualty which will be more difficult than ever for the psychiatrist to manage It may be impossible to correct

Th s type of casualty is no different from the invalidism which may follow an ill advised or unsuccessfully performed abdominal operation The plastic surgeon must forever be on guard against persuasion to operate on the subjective type lest he not only fail to benefit him but even do harm to him elf and the profession Constant persuasion is one of the ever present signs and deadliest weapons of that type of psychoneurotic

BIBLIOGRAPHY

Andersen A S Mental repercu sion in physical disease J Florida M A 34 259 1947

Anell A J and Rotman D B Psychopathic personal y J Crim Law & Criminology of Northwestern Univ 39 155 1948

Blair V I and Brown J B Nasal abnormalities fancied and real The reaction of the patient their attempted corrections Surg, Gynec & Obst 53 797, 1931

Burian F Fysiologicke Operovani Knihtiskarna Tiypus V Praze 1945

Grinker, R R Psychiatric objectives of our time, Canadian M A J 56 151 1947

de Gutierrez Mahoney, C G The Treatment of Painful Phantom Limb A Follow Up Study (Surg Clin N Am New York Number) Philadelphia Saunders 1948

Pick J F Ten years of plastic surgery in a penal institution J Internat Coll Surgeons 11 315 1948

Spaeth F B Ptosis—posttraumatic and hysterical Am J Ophth 27 No 7, 1944

Straith C L Plastic surgery its psychological aspects J Michigan M Soc Jan 1937

Straith C L and DeKleine F H Plastic surgery in children The medical and psychologic aspects of deformity, J.A.M.A 3 2364 1938

Wolff H G Holmes T H Goodell H and Wolf S Life situations emotions and nasal disease Cincinnati J Med 27 No 11, 1946

4

Scope and Limitations

The scope of plastic surgery is fourfold (1) the correction of the deforming consequences of disease and trauma for the purpose of improving form and function of a part (2) the reconstruction of congenital defects with a view of improving the individual's economic and social value (3) the ablation of defacements in the hope of improving the individual's emotional integrity or mental hygiene (4) the rehabilitation of the severe battle casualty with the aim of making the individual self sustaining in later civilian life

Until the advent of World War II and the establishment of Plastic Centers by the Office of the Surgeon General of the United States Army (where the work of the plastic surgeon found its first extended opportunity for clarification) it would have been difficult to try to delineate the scope of plastic surgery Curious as this may seem the reasons and the background for this are probably best expressed in the following brief restrospective analysis of Gustave Aufricht

Even after the First World War however the place of Plastic Surgery was not well defined and its place on hospital services was questioned This is partially explained by the fact that the specialty itself was not fully clarified and its boundaries and those of the related fields were still undefined While there were a few hospitals which conducted clinics for the general public they functioned as a partial activity of either the surgical orthopedic or some other department Only a few surgeons could afford to declare their full interest in this precarious specialty *

The implications of the above are particularly revealing because as far back as 1859 Joseph Pancoast during the delivery of a commemorative lecture on Mutter his friend and colleague eulogized the latter as follows

> He had witnessed while abroad the opening of new fields of surgery in which perhaps the greatest of the modern achievements of the art have been accomplished He had seen the great domain of plastic surgery revived from its golden relics and its principles applied by the surgeons of Paris and by Dieffenbach and Liston †

To appreciate more fully Aufricht's considered words and admonitions one has only to look back to 1876 a short 17 years after Pancoast's lecture when Gurdon Buck in his manual§ states in very stimulating phrases what should have marked the beginning of the recognition of not only the long lost art but a new perspective in surgery

> While these cases have very strong claim upon our commiserations they should stimulate us as surgeons to our greatest efforts for their relief as they so often in the past have been dismissed as hopelessly incurable ‡

* Aufricht Gustave The Development of Plastic Surgery in the United States Transactions American Soc of Plastic & Reconstructive Surgery 1944

† Pancoast J A Discourse Commemorative of the late Prof T D Mutter M D LL D (introductory lecture to the course of Anatomy in The Jefferson Medical College of Philadelphia Oct 14 1859)

§ *Contributions to Reparative Surgery in Its Application to the Treatment of Deformities Produced by Destructive Disease or Injury Congenital Defects from Arrest or Excess Development and Cicatricial Contractures from Burns.*

‡ Buck Gurdon Contributions to Reparative Surgery in Its Application to the Treatment of Deformities Produced by *Destructive Disease or Injury* Congenital Defects from Arrest or Excess Development and Cicatricial Contractures from Burns New York D Appleton & Co 1876

All this did not clarify nor even begin to establish the undeniable virility of the surgery of repair. The influence and the autonomy of the established order of things in surgery continued to delay the efforts of a few far-seeing men for many decades to come. This is amply recapitulated in the words of Blair in 1936:

It took a World War to awaken a rather unprepared profession to the need of and the opportunity for this work being well performed.

In spite of later conscientious efforts to give incoming aspirants the necessary double training, no widely applicable and satisfactory plan has yet been emphasized. There is necessarily something approaching a gift back of its higher flights which cannot artificially be called into being, and without a natural flair the work can not go beyond standardized mediocrity. Given the combination of ability and the will to do, both quality and facility of production can be stepped up indefinitely by training and circumstance.*

It took a second World War and the involvement of more than one third of the American medical profession to invoke a more general acceptance of the necessity for this type of surgery. Due to the indefatigable and persistent efforts of a few men who had not entirely forgotten the experiences and the lessons of World War I, plastic surgery finally weathered the storms of incubation and emerged as an accepted member of the surgical faculty.

CORRECTION OF TRAUMATIC

possibilities of surgery than heretofore. These simply recalled the words and the admonition of Gurdon Buck, just quoted.

It is a notorious fact that the total number of severe civilian casualties is equal to or probably exceeds those resulting from war. The material is there and consequently the need. Society in increasing numbers and with more extended effort is demanding of surgery that it apply itself to the betterment of the individual's business, social and industrial value. The plastic surgeon can be prepared to meet the demand only by adequate general training in reconstructive surgery. The modern well-organized hospital must become more and more recognizant of the necessity for establishing surgical services in which opportunity and proper appurtenances will be ready for this purpose.

CORRECTION OF CONGENITAL DEFECTS

The second task of the plastic surgeon, namely the reconstruction of congenital defects, has definitely passed the harelip and cleft palate stage. Undoubtedly one of the greatest deterring factors in the further development of this type of surgery have been surgeons themselves. It is still not completely realized that in the performance of this type of surgery a little more knowledge is necessary than to be able to operate "by the book." This surgical honesty is probably best expressed by John O. Roe (1848

With the more ready acceptance of plastic surgery by the American surgical faculty as a whole and the consequent increasing admission of the congenital deformity as a pressing surgical problem courage sometimes takes precedence over compassion in this field on the part of the occasional operator The apparent ease and simplicity of certain plastic procedures tempt one to operate such cases by the book Unavoidably the plastic surgeon sees accumulating evidence of the lack of understanding of the principles of proportion and symmetry in the results coming from the hands of those who have not become fully conversant with the necessity for the esthetic results which are the inseparable part and parcel of this work The simple and elemental ablation of congenital defects is no more acceptable to adequate repair than the Langenbeck closure of a cleft palate or the Brophy procedure for the same condition

These simple principles of proportion and symmetry must in all obedience to logic be extended to the repair of other conditions than those affecting the face The same applies to the repair of the hypospadii atresia of the anus or the vagina the web hand the congenital ear and all such other conditions as are entitled to more than simple incision amputation and closure

With the proper knowledge and appreciation of all the factors which enter into adequate reconstruction there must ultimately come the general recognition of the extent and the responsibilities of this type of work This may be more fully appreciated by the student after studying Sections II and III

PLASTIC SURGERY AND MENTAL HYGIENE

One of the greatest tasks of plastic surgery particularly in civilian practice is the ablation of defacements with a view of improving the individual s emotional integrity and mental hygiene This is undoubtedly one of the least recognized and understood functions of the plastic surgeon It is a phase of plastic surgery which must be conceived to have a wider range of purpose than is ordinarily ascribed to it The primary function of all surgery in general—alleviation of suffering—must be augmented and extended where the plastic surgeon is concerned particularly in the light of progress which has been made in the basic sciences psychology and psychiatry

The amelioration of physical pain by surgery is an important factor in its economic value because when pain interferes with the function of a part it interferes with the usefulness of the individual as a whole This leads to a serious economic loss For the same reason its counterpart mental pain arising out of physical aberrations becomes the unavoidable business and responsibility of surgery To resolve such a situation where modern surgical technic and prudence dictate its feasibility is to re orient the individual in society as a beneficent unit In other words where a lesion or a defect definitely and permanently affects the economic or social value of the individual its surgical implications cannot be denied so long as surgical possibilities exist for its correction In the chance denial of this obligation surgery slips into the category of a dogma not only contrary to the social scheme of things but inconsistent with the progress being made in other branches of medicine Constant progress in surgery can be maintained only insofar as the application of its principles discoveries and possibilities keep pace with the needs and the welfare of the individual and of society This is a principle verified by the constant social and economic changes of civilization

The function of corrective surgery as a therapeutic aid in the field of mental hygiene is an undeniable responsibility This point has been stressed by outstanding surgeons for decades and has been ably expressed by John O Roe as far back as the close of the nineteenth century

We are able to relieve patients of a condition which would remain a lifelong mark of

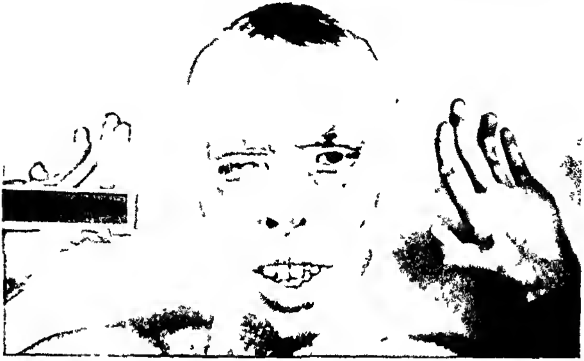

Fig. 12A. Subjects of mortification. (*Top*) Consequences of a flash burn. Note absence of ears. Grotesqueness entirely due to generalized fibrous healing of face. Forehead partially and inadequately grafted, as are the lower lids. Note partial tarsorrhaphy of lids. Patient unable to appose lips. The partial grafting of the face (done elsewhere) is a good illustration of the "patched face." For discussion of latter see Chapter 22, "Full Face Graft." Note ectropion of lips and retraction of the alae. Each becomes an individual problem for reconstruction. (*Bottom*) Rhinophyma (Acne rosacea). This condition may become extreme in its external manifestations without actual involvement of the nasal chambers. The latter may follow careless surgery. (See postoperative Fig. 443, p. 759.)

FIG 12B Subjects of mortification (*Continued*) (*Left*) Congenital failure of fusion of frontonasal processes and maxillae The mortification in such cases rests with the parents (*Right*) Dystocia of facial bones with septal deviation to the left and bilateral deformity of external auditory meatae resulting in strangeness of profile and expression

disfigurement constantly observed forming a never ceasing source of embarrassment and mental distress to themselves amounting in many cases, to a positive torture as well as often causing them to be objects of greater or less aversion to others

It will be a surprise to any physician who will take the trouble to investigate the subject to find how many brilliant lives how many noble personalities, and how much valuable talent have been so to speak buried from human eyes lost to the world and Society by reason of the embarrassment and mortification caused by the conscious or, in some cases the unconscious influence of some physical infirmity or deformity or unsightly blemish (Fig 12)

The effect upon the mind of such physical defects is readily seen reflected in the face which invariably conforms to the mental attitude and leads after a time to a permanent distortion of the countenance *

* Roe J O The deformity termed Pug Nose and its correction by a simple operation M Rec 31 621 623 1887

In peacetime one is constantly faced with surgical problems the result of natures own mistakes the surgeon s errors the consequence of accidental trauma the result of wear and tear of age which though they may not impede reasonable function of a part nevertheless destroy to a degree the individual s economic efficiency social acceptability as well as his mental well being What the adequate functioning of a physical part means to the individual the proper functioning of the latter means to society Anything which obviously interferes with the proper behavior of the individual or his integrated functioning as a social unit if correctable by judicious surgery ipso facto becomes the responsibility of the surgeon

Baker and Smith interested in the psychic reactions of patients suffering with facial disfigurements have reported the results of their psychiatric examinations in

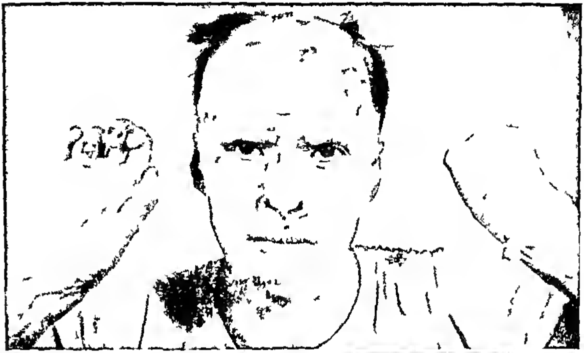

FIG 13A War injuries subject to rehabilitation (*Top*) Extensively and severely burnt patient already ambulatory but still an economic problem until hands are made useful Patient suffered a 64 per cent body burn mostly third degree In this case *homografting* of both lower extremities proved a life saving measure after all other forms of therapeusis proved inadequate (*Bottom*) Severe injury to face with loss of *malarzygomatic compound left eye* lower lid orbital floor and subtotal loss of ear Reconstruction begun via cervical tube for ear and abdominal tube (not shown) for reconstruction of face

war It may perchance signify a new era in military surgery

As far back as the years immediately succeeding World War I a few men some of them in this country like Blair Ferris Smith John Staige Davis Ivy and others and on the European continent Sir Harold Gillies Lexer Filatof and Burian made

Such centers must be under the direction of surgeons specially trained to enable them to prevent insofar as possible secondary deformities and where mutilations already exist to be able to correct them by plastic methods with the final view of improving function as well as appearance To the surgeons working in this specialty it is clear that much better results could be obtained if knowledge of the principles of plastic surgery were the property of all surgeons in the field and if organization of this type of surgery for purposes of war preceded such an eventuality

NOTE Parentheses are the author s

The enumeration of the various functions *of plastic surgery in themselves do not* necessarily establish a basis for plastic surgery as a specialty The basis becomes clear only when the basic and underlying factor behind all these functions becomes evident This factor is the element of repair which as a basic concept in plastic surgery on the scale of general applicability is what differentiates it exclusively from the older surgery Repair of the defacements and the defects of the human body acquired or congenital has failed of recognition in the past due to the persistence of the old and deep seated prejudices against prostituting the surgeon s work to the point of esthetic appeal Yet the surgeon himself in his discourses never hesitates to refer to the Art of Surgery (see Chap 23)

The conventional procedures of the older surgery when reduced to a common denominator all more or less follow the simple equation of incision excision closure Surgery maintained on that level remains a form of therapeusis in self defense It is an admission of self limitation if not weakness For it thus professes to do nothing more than to excise or separate the pathology from the healthy remains One is forced by logic then to assume that the healthy remains are equal to the original or even better The tenet is obviously unreasonable when maintained it becomes a dogma ad absurdum

From the standpoint of the sociologist the psychologist the economist and the psychiatrist such a proposition could not stand the test of unbiased scrutiny From the standpoint of scientific progress such an attitude is pure staticism It becomes understandable then why the idea probably as old as human thinking of reconstituting the original human pattern should keep reasserting itself as it had with the Hindus the Egyptians and later the Caucasians It is apparent that if surgery is to progress and survive as an integral and indispensable part of the social scheme it must rise from the doldrums of the therapeusis of Despair (amputation) to the more physiologic and creative level of Repair (reconstruction)

LIMITATIONS

It would be difficult at this time to hazard a reasonable outline of the possibilities in tissue transplantation repair and reconstruction The delineation of the final possibilities of plastic surgery must await further developments in the basic sciences as well as additional experience in the operating room

The limitations in this field for the present are governed mainly by the extent of the deformity the amount of tissue available the adaptability of the available tissue to transplantation and function

The limitations in any particular case of course are further governed by the technical ability of the surgeon and his basic knowledge of the physiologic implications of surgical trauma and tissue transplantation In a case where serial operation is necessary the relationship of the summation of surgical trauma to ultimate function and physiology of the tissue plays an important part in the value of the reconstructive effort

Ultimately certain limitations are placed against any surgical effort as has always been the case in medical history by professional as well as social attitudes Because of the failures for instance attendant upon

the performance of hysterectomies in the first stages of the development of that operation several states passed laws forbidding the operation as being too dangerous or even impossible of successful accomplishment In no small measure was the profession itself a part of this attitude Insofar as plastic surgery is concerned much will depend upon the social need and recognition of such surgery together with future economic and social developments

From a purely clinical and scientific standpoint however it may be said that for the present at least we have only scratched the surface Notwithstanding it may be held that whereas the surgery of excision and amputation is limited only by the individual's ability to withstand and profit by such surgery in the reconstructive field the limitations would seem to depend as much upon the biologic potentialities of the tissues Of these we know too little Certain it is that modern surgical technics and armamentaria have far outstripped our knowledge of tissue potentialities Only when that knowledge has been brought up to our skills will the limitations in plastic surgery become evident The field of plastic surgery remains for the present a field for most fertile research

casualties in North Africa and Italy J Oral Surg 3 112 1945

Cutler K Progress in acrylic conservative technique—an evaluation of its present scope Int Dent J 77 1 1944

Gallie W F Ideals in surgery Surg Gynec & Obst 84 No 4A 1947

Gillies H D Plastic Surgery of the Face Oxford Med Pub 1920

Gruenwald P A survey of congenital anomalies as found in 11 1 necropsies Illinois M J p 55 Jan 1941

Ivy R H Early and late treatment of the face and jaws as applied to war injuries The South Surgeon 11 366 1942

——— Plastic surgery in combat and civilian casualties M Ann District of Columbia 13 No 2 1944

Ivy R H Kirkham H L D Brown J B Gallagher J L Straatsma C R and Hemberger A C Plastic and reconstructive surgery Clinics 2 116 1193 1944

Kapel O Cat Bite—Pasteurellosis—Halisteresis Acta Chir Scandinav 95 Fasc 1 11 1947

Kessler H H Amputation lessons from the war Am J Surg 74 No 3 1947

King B T New concepts of the etiology and treatment of diverticula of the esophagus Surg Gynec & Obst 85 No 1 1947

Leopold I H and Adler F H Use of frozen dried cornea as transplant material Arch Ophth 37 268 1947

Owens Neal Skin grafting Its relation to general surgery J M A Alabama Aug 1935

Palmer A Training in plastic surgery—visual aids Plast & Reconstruct Surg 1 No 1 [illegible]

Straith C L and Pilling M A Plastic surgery in industry Am J Surg 74 No 3 1947
Sutton L E Plastic surgery in the treatment of war casualties Am J Surg (N S) 61 No 2 1943
Swan C Congenital malformations in infants following maternal rubella during pregnancy A review of investigations carried out in south Australia Tr Ophth Soc Australia (Brit Med Assoc) 4 1944
Swan C and Tostevin A L Congenital abnormalities in infants following infectious diseases during pregnancy with special reference to rubella A third series of cases M J Australia p 645 May 11 1946
Swart H A *Reconstructive surgery in an Army General Hospital* West Va M J March 1947 p 107
Wright Sewall *The hereditary factor in abnormal development* Proc Inst Med Chicago 11 385 1937

other treatment he had if any Where a previous corrective procedure has been attempted it is imperative that the surgeon not make the mistake of operating again before the lapse of sufficient time to permit the tissues to retrieve their original integrity To re enter a recently operated field too early is to court the probability of a prolonged convalescence and delayed period of functional restitution A defect which has been operated upon several times only augurs the probability of another failure unless a detailed and informative history brings out most reliable information as to the reasons for previous failures In connection with the rehearsing of the clinical course and events of former operations the surgeon will get a fairly reliable idea of the co operation he may expect from the patient postoperatively The patient s conduct and habits often have much to do with the end results of a corrective procedure

Under the heading of Other Forms of Surgery one may be able to gain from prior postoperative experience of the patient a fairly reliable idea of what to expect in the way of healing

The above are only a few of the salient points which must be brought out in the taking of a history prior to any corrective procedure in order that one may be well oriented as to the surgical difficulties and the personality problems A more comprehensive inventory will be found in the attached history form which has been employed with sufficient success and saving of time so that its study if not its adoption may be of help to the student in plastic surgery in the formulation of plans of treatment and conduct of the case (Form 1)

FORM 1

HISTORY

No Date

Name Relative

Address Address

Tel No Occupation

Occupation Ref by

Age Civ Status Address

COMPLAINT (Patient s own words)

DIAGNOSIS

Surgical

Psychological

CLINICAL HISTORY

Date and Cause of Defect

other treatment he had if any. Where a previous corrective procedure has been attempted it is imperative that the surgeon not make the mistake of operating again before the lapse of sufficient time to permit the tissues to retrieve their original integrity. To re-enter a recently operated field too early is to court the probability of a prolonged convalescence and delayed period of functional restitution. A defect which has been operated upon several times only augurs the probability of another failure unless a detailed and informative history brings out most reliable information as to the reasons for previous failures. In connection with the rehearsing of the clinical course and events of former operations the surgeon will get a fairly reliable idea of the co-operation he may expect from the patient postoperatively. The patient's conduct and habits often have much to do with the end results of a corrective procedure.

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HISTORY

No.	Date
Name	Relative
Address	Address
Tel. No.	Occupation
Occupation	Ref. by
Age Civ. Status	Address

COMPLAINT (Patient's own words)

DIAGNOSIS

Surgical

Psychological

CLINICAL HISTORY

Date and Cause of Defect

Nervous____________________

Skin____________________

Other____________________

PARTICULAR

Type of Defect

Functional Implications

Complications

Tissue Environment

LABORATORY & X RAY

DISPOSITION OF CASE

SURGICAL PLAN OF PROCEDURE

SURGERY

HOSPITAL Record No Date

TYPE OF SURGERY

P O COURSE (24 Hours)

(100 Hours)

P O RESULTS (10 Days)________ (6 Months)________

(30 Days)________ (1 Year)________

(3 Months)________ (5 Years)________

I________________herewith give________________M D , and/or his assigns, unrestricted authority to use any and all materials in connection with my case (viz X rays, Photographs, Moulages, Specimens, et cetera) for scientific and teaching purposes with the understanding that my name shall be omitted in the use of the materials

Date________ Witness________________ Signature________________

6

Physical Examination

A thorough physical examination is as relevant to the delineation of an appropriate surgical plan as a comprehensive history is to a telling diagnosis

The physical examination of a patient who is a potential candidate for a corrective surgical procedure must be divided into two distinct phases (1) the general physical examination in order to ascertain fitness for any form of surgery and (2) the particular inventory of the defect or defacement for which the patient seeks relief

GENERAL EXAMINATION

As in any examination preceding surgery all vital information concerning the patient s cardiac respiratory renal and neurologic status available should be elicited and recorded

Since the plastic surgeon more than any other has to bear in mind constantly the influence of reconstructive surgery upon the well being of the individual as a whole not only from a physical but also from a psychological standpoint it is pertinent that some attention be directed to the correlation of the body type with the personality The psychosomatic integrity of the individual is an important factor in the management of plastic problems Corrective procedures of a somatic nature unavoidably implicate the psyche of the individual Karl C Seltzer in Body Disproportions and Dominant Personality Traits published in Psychosomatic Medicine (8 85 March April 1946) reports on a large number of cases in which he has taken physical measurements and attempted to evaluate their relationship to dominant personality traits From the examination of 258 normal young men he has come to certain tentative conclusions The body disproportions that Seltzer has weighed against personality are stature of body to weight shoulder width to circumference of chest size of head as compared with size of chest and weight of hand as compared with body weight

The men who were more frequently afflicted with certain dominant personality traits were those whose stature was tall for their body weight whose shoulders were too broad for the circumference of the chest and whose hand seemed to be out of proportion in comparison with body weight They were ultimately men of lesser stability lesser integration greater sensitivity and complexity of personality and lesser capacity for making easy social adjustments Seltzer goes on to say that the traits which go with these body disproportions as mentioned above are unstable autonomic functions mood fluctuations inhibited cultural less well integrated

The hypothesis does not sound unreasonable and may be used as a guide in personality diagnosis It coincides to a degree with the clinical experiences of the psychiatrist It seems to be a commonly accepted fact that some general relationship does exist between body contour physiognomy proportion relationships and the individual personality

SKIN TIMBRE

The next point on the agenda in a general physical examination is to make a thorough general survey of the timbre and the condition of the skin One should be on the

body, color selective amount of moisture elasticity, amount and quality of hair growth pigmentary changes circulation and innervation of the skin The importance of this lies in the fact that in the hands of the plastic surgeon the skin is a working material The quality of the skin is as important as the quality of the surgeon s instruments in its influence upon the eventual outcome of any procedure No matter how meticulous the technic and how fine the quality of the instruments if one is forced to work with skin of an inferior timbre one must be reconciled to inferior results

There are certain normal variations in skin thickness texture and timbre which it is well to bear in mind For instance the skin is thinnest on the scrotum the anterior facies of the auricle the eyelids the dorsum of the hands and the medial aspect of the upper arm in about that order On the other hand it is thickest on the soles of the feet the palms of the hands the buttocks the back the dorsal cervical region and the scalp in about that order

The elasticity of skin in various locations also varies normally This variation is not only observable in one individual as compared with another but in the same individual in different parts of the body It is least elastic in general where it is thickest It is most elastic as a rule where it is thinnest There are other factors of course which influence the elasticity and the timbre of the skin such as age general health the amount and the kind of adipose tissue subjacent to the skin as well as the quality of the elastic fibers within the derma Ordinarily the skin is most elastic over the eyelids the anterior neck the under surface of the upper arm the dorsum of the hands the lower abdomen the scrotum the inner surface of the thighs and the region above the knee

A meticulous skin survey is not only important from the standpoint of the usefulness of the skin as a reconstructive material but also because occasionally the surgeon is able to detect general afflictions of which the patient himself may not be aware These may prove to be contraindications to any extensive repair

If after a general examination of the patient he is established as a good surgical risk and if after a specific inventory of the skin it gives promise of being good material the final stage of the examination may proceed This consists of a particular examination of the defacement or defect of which the patient complains

PARTICULAR EXAMINATION

The examination of any individual defect or defacement should be as thorough and systematic as the general examination itself In other words one should get into the habit of a planned and progressive manner of inventory of the defect as is practiced in the examination of the patient as a whole or of any organ This resolves itself into a particular or focal examination by inspection palpation percussion auscultation and occasionally transillumination

Inspection

Proper and thorough inspection of a defect will give information of inestimable value The inspection of a defect or a lesion should be divided into two parts First a gross inspection should be made which consists of the determination of the type and the extent of the defect whether there is presence of abnormal tissue or absence of normal tissue size of the defect involvement of collateral tissue as well as of function approximate age of the lesion color presence of neoplasia or infection and the amount of scarring Such general inspection will give not only a clue as to the type of defect but also to the probable extent of surgery indicated Second a more detailed inspection or micro inspection of the defect may be helpful A micro inspection is done with a magnifying glass If carefully performed it will give information which is as near a micro anatomic analysis of the



complaint as is possible without actually doing a biopsy This type of inspection may result in more detailed information as to the blood supply the lymph supply and the quality of the tissue which comprise and surround the defect (Fig 14)

Inspection may be further augmented by the use of *ultraviolet or infra red photography* In general it may be said that ultra violet rays are helpful in revealing details of tissue pathology whereas infra red offers *better information as to the physiologic* condition of the tissue examined

The importance of careful inspection of a part may be specifically illustrated by the following case A physician at one time an amateur pugilist presented himself with the request for correction of a nasal deviation Since this deviation was associated with a prominent hump of the nasal dorsum it was his desire that this be removed at the time of the correction of the deviation Upon close inspection of the nose with a magnifying glass the suspicion arose that there was an unusual amount of fine telangiectasis in the skin with atrophy of the glandular elements which could not be accounted for on the basis of the trauma Further questioning of the physician patient revealed that approximately five or six years prior to date the patient had had some type of cutaneous eruption on the nose which was treated by X rays The skin eruption had disappeared and he had very logically forgotten about the incident

In view of the foregoing it was felt that a corrective surgical procedure should be *postponed Eight months later the patient* presented himself again with two pinpoint ulcerations on the right side of the nose in an area of rather prominent telangiectasis which areas of minimal ulceration had now been present for several weeks He was advised to have a biopsy done The results of the biopsy showed extensive endarteritis with microscopic cellular changes of neoplasia and degeneration rather characteristic of a late tissue change associated with radio dermatitis

It was felt that sufficient clinical as well as laboratory evidence existed for radical excision of the soft tissue overlying the dorsum of the nose This was done and a skin graft was applied

Had rhinoplasty been performed when the physician requested it it is not improbable that complications in the soft tissues overlying the dorsum of the nose may have been precipitated necessitating prolonged reconstructive surgery

Fig 15 Considerations in physical examination influencing planning of reconstruction (*Top*) Consequences of blast burn *General problems* none *Essential problems* face—vision expression appearance respiration available tissues for reconstruction hands—integrity of present grafts scarring function appearance available tissues for further reconstruction Correlation between the two sets of essential problems necessary before any plan of restoration is valid

(*Bottom left*) Gross derangement of facial structures from propeller injury *General problems* possibility of past cerebral involvement loss of cerebral fluid due to basal fracture malnourishment and possible anemia—the result of inability to masticate and anoxia due to difficulty in respiration *Essential problems* multiple fractures of facial bones double vision hence special investigations of various facial entities indicated Both general and essential problems must be reconciled before any reconstruction is undertaken

(*Bottom right*) Healed war wounds of right arm *General problems* none *Essential problems* complete evaluation of degree of functional loss amount of scar tissue to be excised quantitative postoperative tissue void timbre condition and quantity of collateral tissue available for repair and finally orthopedic implications and the postoperative problems these present as to bone grafting donor site splinting etc (For postoperative one stage soft tissue reconstruction of injury see Fig 277 p 523) Tubed pedicle on left abdomen not intended for right arm

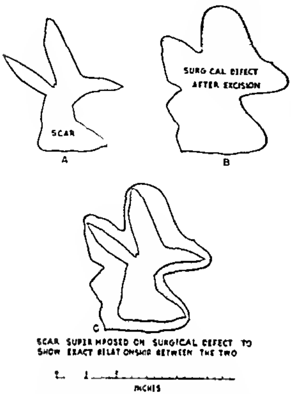


FIG 16 Relationship of scar to surgical defect (A) Represents exact reproduction by pattern of scar on left jaw following compound fracture (B) Exact pattern of surgical defect after excision of scar (C) Comparative study of the two by superimposition This element of relationship of surgical defect to excised scar must always be uppermost in the student's mind when planning tissue revisions

Thorough and thoughtful inspection has no substitute To understand what one is looking at determines the importance of inspection (Fig 15)

PALPATION

Palpation is on a par in import with thorough inspection Where the surgeon is faced with the problem of excision of a lesion meticulous palpation of all the tissues relevant to the defect including the surrounding tissues is indicated

In the first instance the lesion should be palpated to determine its extent and relationship to underlying as well as collateral tissues The possible presence of foreign bodies pus pockets aneurysm or neoplasm within the confines of the lesion may also be elicited Its involvement of or relationship to underlying structures such as muscle cartilage bone fascia or other anatomic structures should be determined This is not only important in delineating the extent of the surgery but fully as important in the choice of proper reparative procedures

Next is the palpation of the tissues collateral to the lesion Upon the quantity and the quality of these as well as the lesion may depend the decision of a one stage or multistage procedure

This is particularly important in the palpation of defects or lesions consisting of or associated with scars Any scar or scarred lesion when excised will always leave a surgical defect considerably larger than the apparent extent of that lesion This is due to the fact that as scar tissue forms the collateral normal tissue is drawn more and more into the defect whereas when the scar is excised the tissues collateral to it immediately retract more or less into their original position At times this retraction of tissue can be so severe that unless one is prepared for it great surprise or disappointment can be met with at the time of the operation Either not enough collateral tissue will remain for immediate correction of the defect or if one insists on correcting it under such circumstances by forcing tissues into the void Deformity may be replaced by a monstrosity (Blair)

The relationship existing between a scarred defect and the surgical defect resulting from the excision of the scar is best shown by the accompanying illustrations which are accurate reproductions of the original defects as well as the surgical void remaining after the excision of the scar (Fig 16)

With experience comes knowing palpation which is especially important in war surgery where the presence of complicating

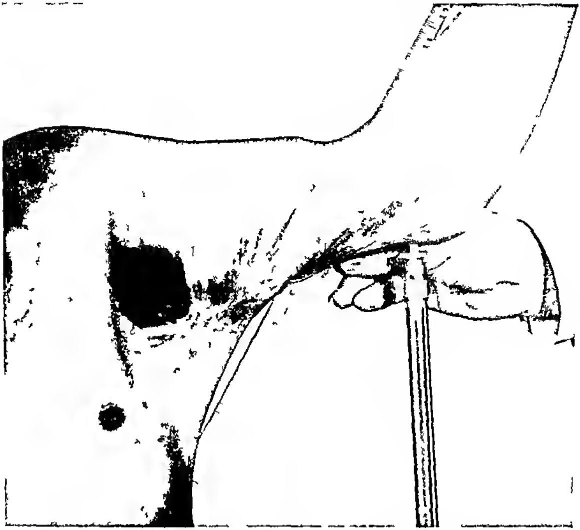


FIG 17 Tissue inclusions in scar illustrating complete rotation of left axilla and distortion of its contents pulled into scarred web Result of a childhood burn Note prominence of both axillary artery and vein within dome of axilla turned 90° to normal Much caution must be exercised in excision of scar tissue (For postoperative result see Fig 278)

factors such as foreign bodies pus pockets or aneurysm is not unusual and obviously affects the plan of treatment It is therefore absolutely necessary that this phase of the physical examination be carried out most thoroughly Where any suspicion of extraneous or foreign material is aroused by palpation it should be checked by X rays

AUSCULTATION

Occasionally, and not rarely, auscultation is of inestimable value in focal diagnosis This is particularly true of lesions or scars overlying cavities and large blood vessels

It is not impossible for an extensive scar to be closely adjacent to a viscus or a cavity or to include within it a large blood vessel or aneurysm Auscultation may reveal such situations Where elicited they always materially influence the surgical plan Where missed they as materially embarrass the surgeon and adversely influence the final outcome

This is more frequently true in traumatic

defects of the chest and abdomen Extensive scars of these parts may include within them a part of a viscus like the intestine or the bladder (Fig 17).

These complications are not unknown as inclusion problems in congenital defects as well When the latter involve joints or the flexion areas of extremities, the presence of large blood vessels or aneurysms is not a rarity To excise what otherwise would seem to be a simple scar and run into such a complication is always an embarrassing situation and can well be avoided by the simple expedient of careful auscultation

In extensive war wounds of the head, the face and the neck, such inclusion complications are more the rule than the exception This occasionally applies to healed gross defects or disfigurements following automobile accidents or industrial injuries in civilian life

Percussion

Percussion is as important an adjunct to auscultation as palpation is to inspection Obviously if the scar or the defect is over a known viscus hollow organ the chest, or the cranium, it is the better part of wisdom to remember to percuss As a rule, in these cases, very light percussion is much more informative than the usual heavier type of examination practiced in general diagnosis

At the conclusion of such a systematic examination of a part, one usually ends up with sufficient evidence to make a satisfactory surgical as well as pathologic diagnosis The proper interpretation of such findings and their relationship to the surgery indicated is discussed in Chapter 9 on "Diagnosis."

BIBLIOGRAPHY

Berens C Aging process in eye and adnexa Arch Ophth 29 171, 1943

Cowdry, E V Cooper Z, and Smith W Program of research on aging of the skin J Gerontol 2 31, 1947

Gillies H D Plastic Surgery of the Face Oxford Med. Pub, 1920

Lexer, E Wiederherstellungs Chirurgie Leipzig Verlag Von Johann Ambrosius Barth 1920, p 360

McBride E D Disability Evaluation Philadelphia London Montreal Lippincott 1948

MacBryde C M Signs and Symptoms Philadelphia Lippincott 1947

7

Laboratory and Technical Aids

The laboratory is a very important aid and source of confirmation to diagnosis in plastic surgery It is on the one hand an inventory of the physiologic state of the patient and on the other hand an evaluation of the pathologic findings

ROUTINE

The routine laboratory investigation of a patient consisting of blood and urine analysis never should be omitted The size the shape and the number of the red blood corpuscles the amount of hemoglobin present the number and the kind of white corpuscles and the platelet count—all have important bearing in selective surgical procedures bearing upon the decision whether or not to operate In selective surgery quality of healing is of paramount import The phenomenon of healing is largely dependent upon the quality of the blood and the integrity of the blood vessels

The detection of any definite pathologic changes by routine laboratory examination of the blood such as dyscrasias whether idiopathic or secondary leukemias and unusually low platelet counts are ipso facto prejudicial to any form of corrective surgery It has been amply proved both clinically and experimentally that the amount of hemoglobin in the blood has a definite relationship to the rate of healing It is therefore a good general rule in plastic surgery never to operate upon a patient whose hemoglobin per cent has reached 75 or below Even then it is good practice to augment the hemoglobin content by transfusions of whole blood If the hemoglobin is below 70 and particularly if the platelet count is low one is courting trouble by the decision to operate Postoperative bleeding venous stasis and skin discolorations are common in such patients No elective surgery should be performed on a patient whose red blood count is below 3 500 000 Where reconstructive or corrective surgery is imperative rather then elective the operation should if at all possible be done only after sufficient blood transfusions have been given to show a marked improvement in the blood picture

Special blood examinations are necessary only infrequently but they never should be omitted if indicated by the history or the general physical examination If these suggest the probability that some general condition such as malaria tuberculosis diabetes or syphilis may exist parallel laboratory work must be done

ROENTGEN RAY EXAMINATION

X ray apparatus is as indispensable to the plastic surgeon as it is to the general or orthopedic surgeon It may be only a means of making a complete diagnosis particularly in defects adjacent to or involving bony structures On the other hand it may be the only means of determining definitely how much tissue and what type of tissue will be necessary in the reconstruction of a defect If there is any reason or suspicion that a foreign body may be involved in the defect the roentgen ray examination becomes an indispensable means in the determination of its nature size and position (Fig 18) Foreign bodies may not necessarily be of extraneous origin They may be displaced teeth fragments of bone foci of

calcification within tissues other than arteries or wire sutures and ligatures remaining after previous operations Knowledge of these things is indispensable to proper planning of the treatment as well as the eventual outcome of the case

Fig 18 Foreign bodies in defects (*Left*) Gunshot wound of right arm showing points of entrance and exit Wound originally excised and covered with epidermic graft without adequate exploration (*Right*) Roentgenogram illustrating fallacy of closing wound without proper exploration Foreign body (metallic) still present and responsible for nonunion

Biopsy

Biopsy unfortunately is an infrequently practiced laboratory procedure As has been indicated heretofore, proper tissue diagnosis in plastic surgery involves a kind of microscopic analysis of the defect or lesion with which the surgeon is dealing For the latter reason alone it would seem that biopsy would hold a more important place in the diagnosis of traumatic or congenital lesions and the tissue dystrophies attending them Particularly is this true where no actual lesion exists but rather a tissue distortion

The reconstruction of many distortions necessitates minute knowledge of the integrity of the tissues collateral to the problem This information occasionally can only be obtained through a properly performed biopsy

Obviously where there is any suspicion of a neoplastic change in a defect or the presence of an actual neoplasm biopsy must be done (Fig 19) Nevertheless there are situations particularly in connection with congenital defects where microscopic pathologies exist within the tissues adjacent to the defect which are neither observable on inspection nor can they be elicited by palpation These veiled pathologies cellular rests minute cystic inclusions and other such conditions not easily detected upon ordinary physical examination but very often suspected must be ascertained preoperatively because they exert great influence upon the eventual outcome of such a case

An outstanding example of this type of situation is found in congenital deformities of the ear The gross deformity of the ear is frequently attended by cellular rests in the portions of the ear present these cells have undergone cystic degeneration or other forms of neoplasia so that following incision or dissection into such parts of the ear as are present postoperative necroses or alterations in the tissue occur which invariably lead to nullification of the object of the reconstruction If these cell groups are exceedingly few the quality of the reconstruction or repair may remain unaffected However where the congenital tissues present are literally studded with such cell groups the correction of the defect will be unsuccessful and frequently must be followed by more extensive or even total reconstruction of the part Such things prove to be expensive in terms of tissue cost as well as time and can be avoided by a judicious biopsy of the congenitally deformed tissues present

These situations are not infrequently encountered in connection with congenital as well as traumatic deformities of the eyelids lips anus vagina the male genito urinary organs as well as other parts of the anatomy

Fig 19 Metaplastic inclusions in defects Epithelioma within scar of healed compound fracture of mandible (For one stage excision and repair see Fig 31)

In extensive tattoos or pigmentary changes of exposed parts and particularly where a full thickness free skin graft is contemplated a biopsy always should be done of the tattooed region This is particularly true of tattoos which are the result of foreign bodies such as gunpowder steel particles or cinders for they have a notoriously prominent penetrating value These often penetrate not only the entire thickness of the skin but are found embedded in the subcutaneous tissue or even in tissues at a deeper level If such bodies are few and of

large caliber sometimes they can be enucleated after excision of the overlying tissues But where the size and the number of particles is such that enucleation is impracticable or impossible after excision of more superficial tissues the surgeon may find himself faced with a bed for grafting which is anything but suitable A preoperative biopsy of more than one part of an

FIG 20 Biopsy of submaxillary gland Note meticulous isolation for inspection and palpation of gland so that tissue desired for biopsy can be chosen with accuracy Where surgical pathology indicates malignancy complete biopsy excision is thus easily performed

extensively tattooed area will aid greatly in the determination of procedure and method of surgical correction When a biopsy is done in such cases the tissues made available for the microscopic examination should be adequate enough in depth to determine both the level to which the foreign particles have penetrated and also their nature This then will guide the surgeon before operation in determining the depth to which excision must be done and consequently will apprize him of the amount and the kind of tissue which will be necessary in the repair

A biopsy well thought out adequately planned and judiciously executed is not a costly procedure and often pays big dividends in the end It cannot be done adequately in a nonchalant or haphazard manner The pathologist can report only upon what he has received for examination The results which he obtains in preparing and examining the biopsy depend entirely upon the quality of the tissues that the surgeon submits for examination

The most common mistakes in the performance of a biopsy are the taking of too little tissue the excision of tissue to an insufficient depth poor delineation of the tissues marked for excision the removal of tissue irrelevant to the pathology suspected postoperative mutilation and traumatizing improper management of the tissue after excision such as allowing it to dry before placing it in solution wrapping biopsy specimens in gauze which is moist

FIG 21A Biopsy excision (*Left*) Extent of excision in epithelioma of lip and method of stepoff closure to avoid ectropion (*Right*) Illustrating satisfactory vermilion border after healing of step off closure

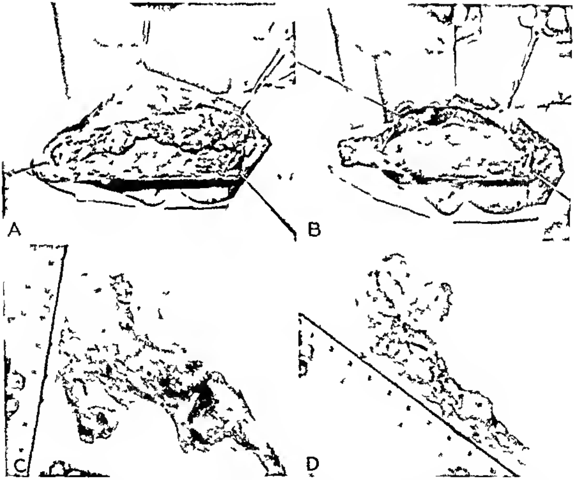


FIG 21B Biopsy excision (*Continued*) Lesion (neurolipoma of left thigh) the size of which is obviously such as to dictate biopsy excision (A) Neurolipoma of thigh exposed (B) Tumor carefully dissected and everted to show nerve fibers penetrating neoplasm (C) Underside of tumor (D) Top view of excised tumor

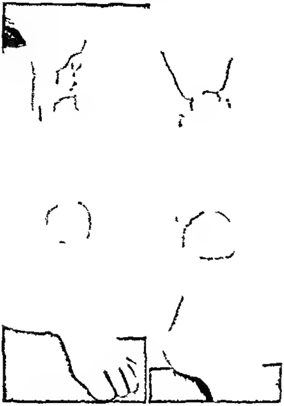


FIG 22 Planned biopsy excision (*Left*) War wound of long standing with signs of malignant change in infrapatellar scar (*Right*) Results of biopsy excision with planned closure by collateral flaps Note metal buttons Wire tension suture is tied over these to splint flaps Lower gunshot wound closed via 'pillowed' flap from other thigh

with harmful solutions storing of tissues in improper temperatures, placing them in solutions of wrong concentrations or consistencies and in other ways disregarding the exacting premises necessary for the maintenance of the quality of any tissue which is intended for the pathologist

A biopsy must be a very guarded surgical procedure of a high order of technical execution done with scientific precision and completed with utmost respect for the cellular structure of the tissue excised as well as the premises determining the proper preservation of that tissue (Fig 20)

BIOPSY EXCISION

There are instances and defects where the surgeon is asked to do a biopsy involving certain parts, afflicted with specific lesions, when the routine procedure is contraindicated This is particularly the case with defects of the lips, eyelids, alae, ears finger tips, prepuce, nipples or penile corona associated with suspected malignant melanoma epithelioma, carcinoma and other diseases (Fig 21) It is a grave error in such cases to do a routine biopsy encompassing only a small portion of the lesion As a matter of fact, it is not sufficient to remove only the lesion per se The best plan in such situations is to do a biopsy excision This implies the total excision of the lesion with an adequate amount of surrounding tissue, even if the latter in some cases means increasing an existing defect or creating an additional one The uncompromising position to be taken is that eradication of the disease takes priority over any esthetic consideration

Nonetheless biopsy excisions always should be planned, as a matter of good surgery, in such manner that closure of the surgical defect is as near consistent with good appearance and function as possible For this purpose certain geometric types of excision are possible in certain locations, preferable to simple guillotining (Fig 22) To this end Chapter 21, "Geometrics in Plastic Surgery," should be consulted

BIBLIOGRAPHY

Burian F Fysiologicke Operovani Knihtiskarna Typus V Praze 1945

Cole W H Laboratory aids in surgery Surg Gynec & Obst 73 122 1941

Gillies H D Plastic Surgery of the Face Oxford Med Pub 1920

Palmer A Training in plastic surgery—visual aids Plast & Reconstruct Surg 1 No 1, 1946

Wolff W A and Lee W E A simple method for estimating plasma protein deficit after severe burns Ann Surg 115 No 6 1942

8

Armamentaria

Armamentaria, when discussed in surgical texts, almost never take into consideration *the* surgeon. Armamentaria in surgery, like materiel in military language, must include "the man behind the gun." No matter what the instrument, it will not operate by itself.

THE SURGEON

Strangely, little is said in textbooks about the extra intellectual fitness of the surgeon. Considerable space, on the other hand, is devoted to the discussion of the type of instruments and the manner of their use, as well as the quality of the material which enters into their making. Yet little or nothing is said about the quality or timbre of the hand—the surgeon—that wields the instruments. The quality of the instrument may indicate what it *can* do, but the hand behind it determines what the instrument *will* do. The best gun never will find its mark without proper direction.

In the words of Professor Burian:

ORIGINAL. Není předepsána zvláštní kvalifikace ani morální ani tělesná pro toho, kdo se *chce věnovati chirurgii. Předpokládá se že* jen ty nejlepší povahy si vyvolí vznešenou lékařskou dráhu. Přece však je nutno důrazne připomenouti, že chirurg musí býti stále v tak dobrém stavu tělesném i duševním, aby se mohl kdykoli postaviti před nejtežší úkol. Znamená to mezi jiným mnohé odříkání a ukázněnou životní správu. Chirurg musí také věnovati určitou péči svým pracovním orgánům, rukám a prstům. Začátečník učiní dobře, když si bude zvláště cvičiti ruce a prsty, i když *naprosto není třeba* aby se stal equalibristou.*

TRANSLATION. There exist no prescribed special qualifications, either moral or physical for one who desires to devote himself to surgery. It is assumed that only the very best individuals choose this lofty road. Notwithstanding, it is necessary to emphasize that the surgeon at all times be in such good physical and emotional condition as to be equal to the most exacting tasks. This implies, among many other things, considerable self denial and exemplary living. The surgeon must additionally devote specific care to certain special organs, viz., hands and fingers. The beginner will do well to train his hands and fingers constantly even though it is not expected he become a juggler.

The temperament and the physical fitness of the surgeon is as important as the steel which goes to make up his scalpels. The ordeal of protracted plastic procedures and the requirements of modern surgery demand of the surgeon a robust stamina, a controlled temperament and much self discipline. These things are necessary over and above technical ability. Wherefore, obedience to certain rules of living becomes an indispensable prerequisite to the guarantee of total surgical fitness.

It would seem that the surgeon must almost be blessed with a better than average share of health and vitality. He must constantly keep himself as physically fit as possible in his campaign against the ills and the misfortunes of others. He must develop a kind of phlegmatic attitude toward the little annoyances and irritations of every-day life lest the summation of their effects disqualify him emotionally when calm judgment and serenity are even more important than the specificity of instruments. Proper sleep, regular diet and exercise are as im

* Burian, F. Fysiologické Operování. Prague: Knihtiskarna Typus, 1945, p. 35.

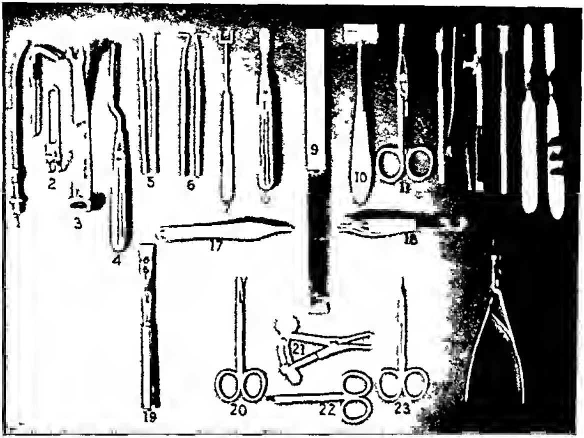


FIG 23 Rhinoplastic instruments (1) Adson suction tube (2) Sheehan retractors (3) Maltz retractor (4) Ballenger swivel knife (5) Single tenaculum (author s) (6) Jameson s hooks (7) Maltz double tenaculum (8) Spoon shaped elevator (9) Lambotte chisel for removal of hump (10) Metal mallet (11) Mayo scissors (12 and 13) Chisels (Pick s) with external guides (14) Chisel (Pick s) with guard (15) Joseph s rasp (16) Berne rasp concave (17) Adson tissue forceps toothed (18) Adson tissue forceps plain (19) Chisel (20) Tenotomy scissors (21) Calipers (22) Wurdemann scissors (23) Iris scissors curved (24) Virtus splinter forceps

portant with him as with his patients Of course it would be agreeable if a certain economic security were the surgeon s lot rather than an aim forced upon him by social conditions provided that the realization of the former did not involve the curtailing of his scientific freedom and professional liberties Obviously a strict regimen and plan of living can be only a thing to strive for rather than to claim since a surgeon has to live in a nonmedical world It is utterly impossible for him to exercise good judgment and deal rationally with the many idiosyncrasies and fallibilities of his patients when he himself feels too tired to eat, too harassed to think or too frightened by economic demands and responsibilities to summon courage to decide

The mechanical shibboleths of modern life place certain dangers in his path demanding special precautions He must constantly protect his hands against all forms of injury, for his hands are his most indispensable instruments He must keep them supple and well groomed and must forever exercise them in the meticulous details and the dexterous maneuvers required of him Constant practice in the operating room

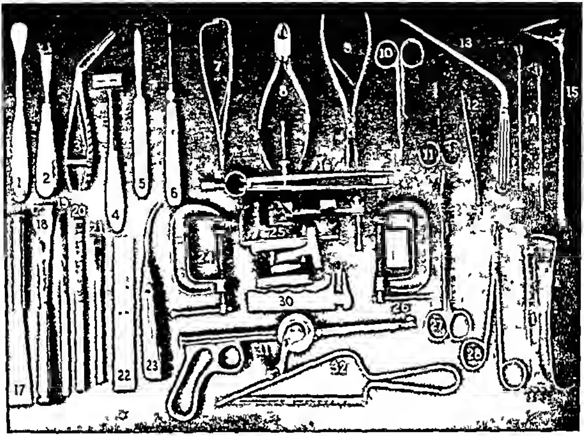


FIG 24 Osteoplastic instruments (1) Sedillot stripper (2) Bacon periosteum elevator (3) Jackson s turbinate scissors (4) Metal mallet (5) Joseph s rasp (6) Reverdin needle (7) Crile needle holder (modification) (8) Wire nipper (9) Lembert rongeur (10) Mayo scissors curved on flat (11) Iris scissors, curved (12) Adson tissue forceps toothed (13) Yankhauer saw (14) Wire loop retractors (Pick s) (15) Beatty retractor (16) Calipers (17) Stille s chisel (18) Stille s chisel modified, curved on flat (19) *Mastoid chisel (20) Mastoid chisel graduated in cms (21) Sheehan chisel (22) Metal* rule (23) Wire carrier (24) Vise clamp (2) (25) Portable vise (26) Drill plate (27) Dean s scissors (28) Gillies needle holder (29) Rake retractors (30) Jameson s caliper (31) Richter bone drill (32) Fine tooth saw with removable blades

makes for perfection but the surgical scheme of things today does not permit the young surgeon to acquire such dexterity and suppleness of hand at the expense of the operating room It is not impossible, on the other hand to set aside time and for mulate certain exercises at odd moments of the day which will increase dexterity in tying and cutting sutures in locking and unlocking instruments and in other details and requirements of modern surgical tech nic At times this can be supplemented by exercises in the dissecting room where such opportunities exist Constant manual exer cises and technical training are as important in the life of a plastic surgeon as they are with a musician if he is to become some thing more than a surgical artisan

ASSISTANTS

Whatever has been said concerning the integrity and the qualities of the surgeon applies to his assistants, associates nurses and, in fact to all who subscribe to being a part of a plastic surgical team As a matter of fact, the value of all those entering into

the life of an operating room depends essentially upon their mutual interest in the work and the ability to act and work as a unit Proper teamwork is indispensable to a smoothly functioning operating theater This of course is in the main predicated upon the fact that whosoever is drafted for the operating room is basically capable and definitely interested in plastic surgery

to an ability at mind reading She must exhibit a good memory for instruments names and procedures, she also needs a degree of imagination so that a single explanation of a proposition is usually sufficient for her to understand what is wanted She must find joy in her task A nurse who takes the attitude that she is just one who hands out the hardware is but one of the

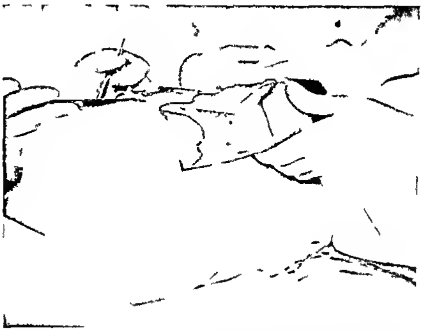
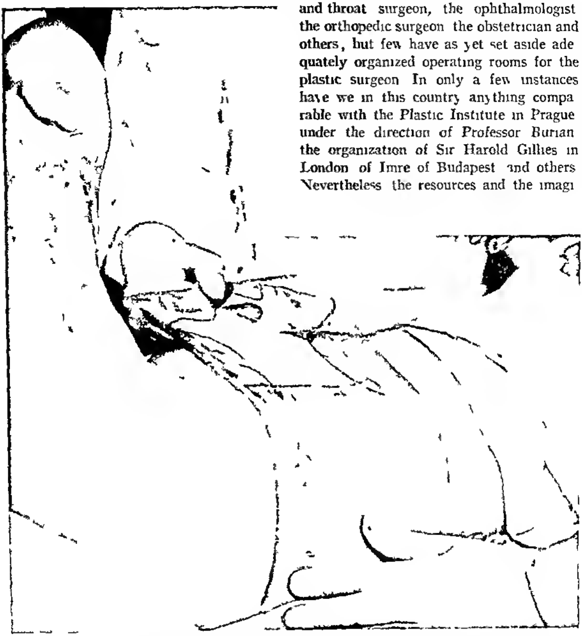


FIG 25A Transparent x ray film as pattern material Use of transparent x ray film on uneven surface Note extensive defect of right arm posterior aspect Film wrapped around extremity Defect outlined by aniline ink Film being lifted for apposition to chest under arm

It is not good practice to assign almost any nurse available to an operating room A nurse so assigned should have first of all the necessary background and training in general surgery She must be definitely interested in surgery She must have certain traits which make it obvious that she will become an enthusiastic helpmate in a surgical amphitheater She must possess certain gifts upon which one can build in order to make of such a young woman an excelleot aid To become a good instrument nurse for instance she must have what amouots

signs of an individual who does not belong The pains of distraction incident to being handed the wrong instruments repeatedly by a nurse and then having to fish for the right one are known to all surgeons To avoid this sort of thing the nurse must have had good surgical training and be able to visualize the surgical procedure In order to acquire this ability she must also have experieoce and imagination This is in large part a responsibility of the hospital or the university involved in the training of a nurse



and throat surgeon, the ophthalmologist the orthopedic surgeon the obstetrician and others, but few have as yet set aside adequately organized operating rooms for the plastic surgeon In only a few instances have we in this country anything comparable with the Plastic Institute in Prague under the direction of Professor Burian the organization of Sir Harold Gillies in London of Imre of Budapest and others Nevertheless the resources and the imagination of this country forebode a brilliant future

Fig 25B Transparent x ray film as pattern material (*Continued*) Before film is extricated from under the arm a line is drawn where film touches the chest wall This indicates allocation of peduncle The line can be seen already drawn under film where it is now in contact with the chest Elevated portion of film shows outline of arm defect

THE HOSPITAL

The hospital is a very important factor in the category of armamentaria It is the custom in all modern and up to date hospitals to have special operating rooms for the genito urinary surgeon, the ear nose

The Institute of Plastic Surgery in Prague is a separate structure, housing several departments, all of which contribute to the work of the general plastic surgeon

Included are a dental department, a nose-and-throat section, a laboratory for research work in grafts, and a large separate section entirely devoted to cosmetic problems, photography, moulage, and a statistical section less a composite of the armamentaria of various specialties which go to make up the surgical scheme Insofar as the aim of plastic surgery is the reconstruction of bodily defects and the correction of deface-

FIG 25C Transparent x-ray film as pattern material (*Continued*). Pattern of flap has been cut out, arm is brought back into apposition to chest and pattern is being rechecked against defect to guarantee accuracy

The necessity for a separate plastic operating room is as pertinent to a well-organized modern hospital as a special operating room for any other field of surgery Since the general plastic surgeon is called upon to reconstruct almost every region of the body, internal as well as external, his operating room must be more or ments in general, it is necessary for the plastic surgeon to use any and all armamentaria of other specialties relevant to the attainment of his purpose. Contrariwise, insofar as any surgeon or specialist wishes to extend his work to include tissue reconstruction, he must be adept in the principles and the procedures of plastic surgery.

with all manner of aids necessary in the induction of variable anesthesia but it must be so located that there is a minimum of noise and traffic within and about Operating room traffic is not only annoying to the surgeon but it also can be quite disturbing to a patient who is not under a general anesthetic Unnecessary talking clumsy transferring of equipment squeaking or banging doors using the patient s body as a leaning board and all other

Fig 25D Transparent x ray film as pattern material (*Continued*) Arm is again posed at right angles to chest and film pattern is spread over the latter Note dark heavy line on chest under film and just above surgeon s left thumb and index finger This allocates peduncle of future flap

THE PATIENT

Since most plastic procedures are long and are executed under some form of local or block analgesia the patient s comfort is a vital consideration Therefore the plastic operating room must not only be equipped

things which in any way might lead to discomfort or fright must be guarded against

INSTRUMENTS

Although basically the instruments used by the plastic surgeon are not much differ

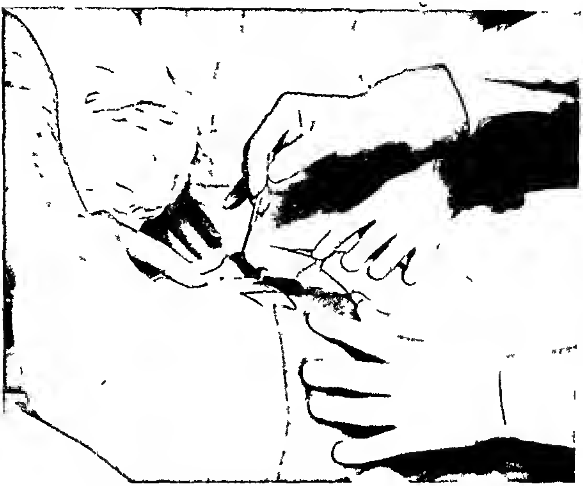
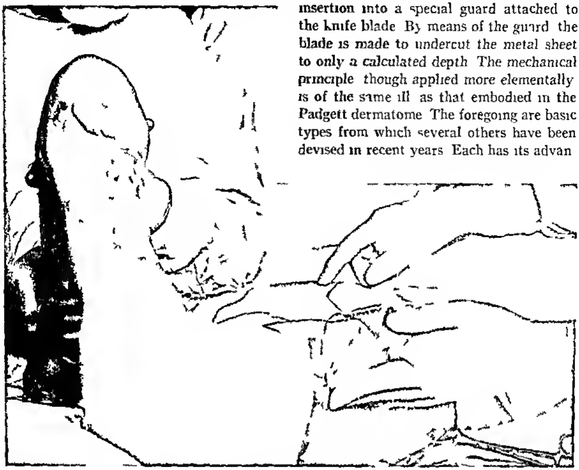


Fig 25E. Transparent x ray film as pattern material (*Continued*) While assistant holds pattern in place an outline of it is traced on the chest wall Note peduncle line in posterior axillary line

ent from those used in other forms of surgery the greater number of them must be of a smaller sharper and finer variety It is the only way in which the plastic surgeon can carry out the fine requirements of his art Wherefore the retractor in plastic surgery is reduced to a simple hook and the knife blade to the smallest practicable size Some authors in an endeavor to gain advantage of the sharpest blade use a razor blade in the place of the ordinary surgical knife There is a limit to the advantages gained from a very sharp instrument The advantages of the types of instruments will be discussed in Chapter 12

The quality and the type of needles that the plastic surgeon must have at his disposal may range all the way from those commonly used by the general surgeon to those of the ophthalmologist Nevertheless the major portion of the work done by the plastic surgeon necessitates for the most part the finest caliber of needles both cutting and round As a matter of fact in this type of work the needle puncture is in itself an important form of trauma Hence the commonly employed saber sized suture needle and the guy rope type of suture material are outside the choice of the plastic surgeon



insertion into a special guard attached to the knife blade By means of the guard the blade is made to undercut the metal sheet to only a calculated depth The mechanical principle though applied more elementally is of the same all as that embodied in the Padgett dermatome The foregoing are basic types from which several others have been devised in recent years Each has its advan

FIG 25F Transparent x ray film as pattern material (*Contiued*) Outline of potential flap is shown traced on chest wall *Note its extension into axilla* This would necessitate flap with wider peduncle thus increasing tissue cost This was not deemed wise and was excluded from actual flap incision and substituted by direct approximation of lips of superior pole of defect as shown in Figure 25G This allowed for easier closure of donor site All the steps in planning are illustrated graphically here although in actual experienced practice modification of the flap to final size would be done mentally The basis of the latter rests on the presence of the tissue excess over the elbow

Certain special instruments are peculiar to plastic surgery Foremost among them are the various dermatomes—instruments used for the mobilization of skin grafts There are several categories of these instruments such as the Blair skin graft knife the Blair Marks knife the calibrated type of dermatomes represented by the accurate machine invented by Padgett and the more simple rolled metal sheets of Caltagirone The last named are metal sheets calibrated in thickness they are glued to the donor site one end being left sufficiently free for tages and certain drawbacks Other special types of plastic instruments are found illustrated in Figures 23 and 24

Aside from the general statement that instruments used in this specialty must be of a smaller caliber and finer quality the matter of instruments is not altogether as important as the surgeon s knowledge ability and manual habits An inferior instrument guided by a superior hand will accomplish surprising results in contrast with one of virgin sheen thrust without compassion into the secret depths of a highly organized

and variable anatomy What the former hand can do with a pet retractor, a pair of tissue forceps and a sharp blade the latter cannot approximate with a catalogue of rare creations

For instruments particularly useful and material are employed for this purpose by different surgeons, ranging from Cellophane and chamois to washed X ray film used by the author The film is easily available, cheap sterilizable transparent, easily handled during the process of patterning and

FIG 25G Transparent x ray film as pattern material (*Continued*) Transfer of thoracic flap to right arm after total excision of scarred tissue Upper and lower extremities of closure (to each side of flap) made possible by undermining thus reducing tissue cost of repair Note small gauze rolls over which are tied critical wire tension sutures to obliterate dead space between flap and uneven recipient site

adaptable to specific operations see Section Three Procedures

PATTERN MATERIAL

Certain aids are instrumental in the completion of the plastic surgeon s armamentarium In order to delineate accurately incisions excisions flaps Z plasties and the transfer of tissue some form of pattern material is indispensable Various types of

does not alter its shape or size with use or time

The manner of use of pattern material is twofold It may be used purely recordwise as patterning material for designing the size and the shape of grafts or as a tracing medium for registering upon it the size and the shape of defects the outline of which can then be utilized elsewhere on the body to determine the size and the shape of the

graft necessary to remedy the defect After the defect has been outlined on the X ray film it can then be cut out of the remainder of the film to make a good permanent record without fear of crushing breaking or spoiling While in use at the time of the operation one can rely upon its accuracy because there is no chance for shrinkage or variation of any of its details Any transparent material which may be sterilized adequately and will not spoil with time is appropriate Opaque materials like chamois are more difficult to work with because they have to be elevated at every turn of a defect to get an accurate pattern of its details This is not necessary with transparent X ray film (Fig 25) The details of the use of pattern material are discussed and illustrated in Chapter 21 Surgical Geometrics

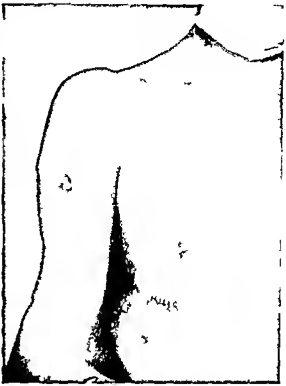


Fig 25H Transparent x ray film as pattern material (*Concluded*) Anterior view of donor site (chest) after transfer of flap Note minimal free grafted area under arm which could not be closed by direct approximation due to size of donor defect without tension beyond submammary closure Arm still attached to chest by flap as shown in Figure 25G

SPLINTING MATERIAL

All forms of splinting material should be at hand The postoperative splinting of soft tissue is more important than the splinting of joints and bones The ordinary splinting material such as wood and plaster of Paris is too frequently inadequate because of its weight rigidity or difficulty of application Things better suited to the purpose of the plastic surgeon are humid cotton adhesive tapes agar preparations tin lead or aluminum sheets waxes paraffin dental compounds stent sea sponges various grades of mechanic's waste or a combination of any of these The specific use and manner of application of these will be discussed in Chapter 19 Splints and Splinting

BIBLIOGRAPHY

Anderson Roger and Erickson H R Glass plastic cast Am J Surg (N S) 69 299 1945

Aufricht G A mirror attachment on the Padgett Dermatome Plast & Reconstruct Surg 3 No 1 1948

Barker D E Throw-away blades for the dermatome Plast & Reconstruct Surg 3 448 1948

Becker O J A nasal speculum for rhinoplastic surgery Plast & Reconstruct Surg 3 No 1 1948

Blaine G Experimental observations on absorbable alginate products in surgery Gel film gauze and foam Ann Surg 125 No 1 1947

Brown A M The place of the prosthesis department in the teaching hospital Plast & Reconstruct Surg 2 No 6 1947

Burian F Fysiologicke Operovani Knihtiskarna Typus V Praze 1945

Campbell E Meirowsky A and Tompkins V Studies on the use of metals in surgery—Part II Ann Surg 116 63 1942

DeKleine E H The Chondrojet Plast & Reconstruct Surg 3 No 1 1948

Gordon S New inventions Maxillary forceps Lancet July 15 1944 p 80

Ingraham F D Alexander E Jr and Matson D D Synthetic plastic materials in surgery New England J Med 236 362 402 1947

Jonas A D Use of a double roll as a bandage Am J Surg 71 365, 1946

Macey H B A new instrument for passing portions of tendons and fasciae latae Am J Surg (N S) 47 No 3

Marino H A suction elevator in the surgery of cleft palate Plast & Reconstruct Surg 3 750 1948

——— Improvements and Modifications of Padgett s dermatome Plast & Reconstruct Surg 3 752 1948

Meyerding H W Set of bone chisels, osteotomes and gouges Am J Surg 74 No 4 1947

Orbach E J New ligation knife facilitating subcutaneous ligation of varicose veins Am J Surg 73 631 1947

Peyton F A Physical and clinical characteristics of synthetic resins used in dentistry, J Am Dent A 30 1179, 1943

Reese J D Dermatape a new method for the management of split skin grafts, Plast & Reconstruct Surg 1 No 1, 1946

Robinson D W Two improvements for the dermatome, Plast & Reconstruct Surg 3 621, 1948

Rubin, L R A new rhinoplastic instrument, Plast & Reconstruct Surg 3 No 1, 1948

Skinner E W The Science of Dental Materials, Second Edition Revised Philadelphia and London, W B Saunders Company, 1940

Slocum H C, O Neal, K C, and Allen, C R Neurovascular complications from malposition on the operating table, Surg, Gynec & Obst 86 No 6, 1948

Tanzer, R C Plastic surgery in a military hospital New England J Med. 235 852, 1946

Ulloa M G A new device for easier skin suturing, Plast & Reconstruct Surg 3 No 1, 1948

Weiss J A Inking pens for skin marking in plastic surgery, Plast & Reconstruct Surg 2 No 1, 1947

9

Diagnosis

Diagnosis is a judicious conclusion as to the nature and the origin of a disease or a defect based upon complete evaluation of all evidence elicited through history physical examination and laboratory investigation Diagnosis in plastic surgery is governed by the same laws and principles that pertain to diagnosis in general If it differs at all it differs in particulars rather than in basic principles Adequate repair in plastic surgery is impossible without a complete diagnosis

Diagnosis in plastic surgery may be divided into three distinct phases (1) the diagnosis of the personality (2) the general physical condition of the patient and (3) the evaluation of the plastic problem As was pointed out in Chapter 6 Physical Examination it is a clinical error to become so engrossed with the nature and the extent of a defect as to forget that one is dealing with a patient It is imperative that one follow a systematic program of history taking general examination and focal analysis of the lesion

The importance of the diagnosis of the patient in terms of a functional unit and occasionally as a personality problem was stressed both in Chapter 3 Psychological Implications as well as in Chapter 6 Physical Examination Therefore it will not be discussed here except to re emphasize its importance

If in the general physical examination of the patient the presence of any systemic disease is detected it must be remembered that this will have its bearing upon the local tissue reaction both during and after the operation Where such conditions as diabetes cardiorenal disease tuberculosis syphilis thyroid disease or other glandular involvement are found such a patient never should be accepted for a plastic procedure except in an emergency

There are unusual instances when in the presence of a systemic disease a plastic procedure may be allowed For instance this problem comes up occasionally in the repair of cleft palate or harelip in infants If a child afflicted with a harelip also has evidence of syphilis the former can be corrected if the syphilitic condition is under control I have seen many such cases operated upon at the Plastic Institute in Prague without complications during the period of healing

PLASTIC DIAGNOSIS

General

Whereas the problems presenting themselves to any surgeon may in a broad sense be divided into two main categories lesions (plus tumors) and deformities even for clinical purposes that is inadequate for the plastic surgeon This must be so as long as plastic surgery is charged not only with the eradication of tissue defects and attainment of functional repair but also with the responsibility of improving appearance of the reconstructed part In other words to the two main categories of surgical problems must be added a third—Defacements

CLINICAL CATEGORIES

For convenience all defects presenting themselves to the plastic surgeon may be divided qualitatively on clinical grounds

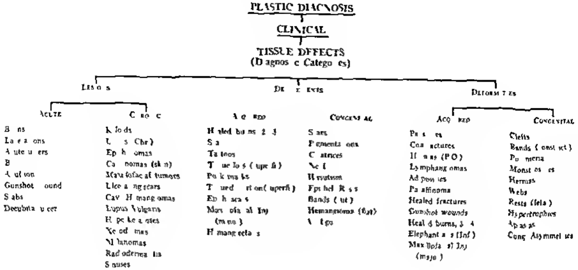


CHART 1

into three categories, that is, lesions, defacements and deformities (Chart 2)

Lesions are active clinical entities, whose activity must first be controlled by some general and/or local measures which may or may not immediately precede correction or reconstruction of the part Defacement and deformities are static clinical conditions, usually of an essentially local character, whose correction is the essential field of plastic surgery They differ only insofar as the former is usually of a more superficial character and involves the appearance of the individual whereas the latter more *pertinently involves the function of a tissue* or form of an anatomic part

Lesions

Lesions may be divided into acute and chronic the latter includes neoplastic conditions

Acute lesions which come to the attention of the plastic surgeon are burns lacerations bites acute ulcerations, avulsions gunshot wounds and others

The chronic lesions consist of certain essentially cutaneous entities ulcers granulomas callosities sclerodermas pigmentations xerodermas, cornifications, sinuses, cystic neoplasias and other metaplasms

Under chronic lesions one may or may not include neoplastic conditions, such as keloids epitheliomas carcinomas maxillofacial tumors paraffinomas and hemangiomas In any case, such a classification is acceptable in accordance with contemporary diagnostic premises

Defacements

Defacements may be acquired or congenital The acquired defacements consist of scars tattoos, healed burns superficial tissue losses, superficial distortions and minor maxillofacial injuries, frequently associated with spot tattoos or minor depressions

The congenital defacements consist of wide superficial scars pigmentations cicatrices naevi hirsutism epithelial rests and cutaneous bands and capillary hemangiomas

Deformities

Deformities may be either acquired or congenital Under acquired deformities, one may place such things as scar contractures hernias, paralyses adiposities, healed fractures with large soft tissue losses gunshot wounds with tissue displacement, healed burns and their consequences, elephantiases maxillofacial injuries of the compound or major types

The congenital deformities frequently encountered in this specialty are clefts, constricting bands, polymeria, monstrosities

hernias webs foetal rests hypertrophies aplasias and asymmetries

Any of the foregoing conditions enumerated under defects may be found classified as lesions in general texts When they eventuate in defacement or deformity or both depending upon their severity they are entitled to quantitative reclassification for purposes of repair

Strictly speaking from the standpoint of plastic reconstruction almost all defects known to surgery in general (listed in Chart 1) may be grouped as tissue aberrations of one or another type This is due to the fact that certain of the conditions listed under Clinical categories (lesions defacements deformities) are quantitatively related This for practical surgical purposes makes them reclassifiable in accordance with the tissue differentials peculiar to them These diagnostic surgical differentials are three in number as depicted graphically in Chart 2

SURGICAL DIFFERENTIALS

The labeling of clinical defects purely in accordance with contemporary terminology is inadequate as a working basis from a surgical standpoint This becomes readily apparent when one tries to visualize the conditions listed under the clinical heading of defects from the standpoint of *functional formative reconstruction* Even the simple scar and congenital band offer greater challenge than mere excision and simple closure Their reparative surgical demands and implications are different from one another although both are tissue defects clinically speaking Finally no accurate surgical knowledge is gained by simply classifying a harelip with a web or either one with the hypertrophic breast under the heading of defects or deformities

From our perspective all such conditions must be analyzed in terms of their basic structural tissue deviations (surgical tissue differentials) which so pointedly formulate and invariably dictate the only type of reconstruction adequate to repair These surgical differentials which indicate suitable procedures in reconstruction are tissue voids tissue derangements and tissue excesses They constitute major aberrations of normal tissue quantity resulting in defective form and abnormal function

Tissue void means tissue lack This may be partial *total* or *relative* The *relative* tissue voids are such as accompany atrophies aplasias dystrophies and scar tissue The presence of scar tissue although it re establishes tissue continuity nevertheless from a functional or esthetic sense simply fills a void In plastic surgery scar tissue implies a relative tissue absence functionally speaking and an absolute tissue want in consideration of appearance

Tissue voids may arise for traumatic congenital neoplastic or miscellaneous reasons The last include such conditions as neurotic excoriations ulcers and clinical conditions consequent upon syphilis or tuberculosis

Tissue derangements may be segmental (restricted) or general (affecting an entire part or appendage) and may be of three kinds a distortion a displacement or a misplacement The most common form of distortion is that due to a scar The usual tissue displacement is due to accident or pressure while tissue misplacement is frequently the result of previous surgery or paralysis From the standpoint of origin any tissue derangement may be traumatic congenital or neoplastic or it may be the result of habit

Tissue excess may be true or false Examples of the true type are virginal hypertrophy of the breasts polymeria and endocrine metaplasis whereas examples of the false type are callus hematomas usually of the organized or partially organized variety lymphadeemas aneurysms elephantiases and tumors Tissue excesses in relation to origin may be traumatic congenital neoplastic metabolic or endocrine

Any tissue aberration may be a combination of any of the three surgical differentials enumerated above—void derangement or excess Whatever the origin or etiology

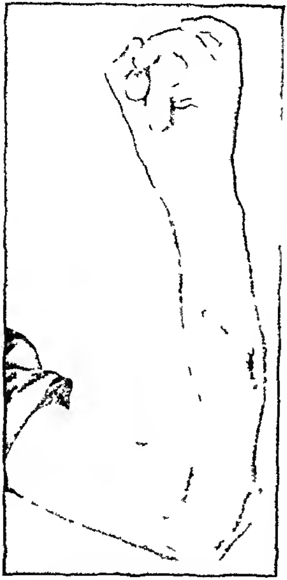


Fig. 26. Traumatic atrophy. Collateral tissue consequences of long delayed repair of gunshot wound (left forearm). Note particular atrophy of palm of hand; also initial spread of massive graft over proximal half of forearm after excision of scar. Donor site—abdomen. Final leveling of graft reserved for time when bone graft is to be inserted into elbow.

of these entities they *must be recognized* as such because they constitute the surgical premise upon which adequate surgical repair is formulated. A working diagnosis in plastic surgery is as *important* as the surgery itself. Where a tissue void exists, an augmented reconstruction is indicated. Where a tissue derangement exists, a correction revision is indicated, and where a tissue excess exists, usually an ablation reconstruction is necessary.

TISSUE VOIDS

Etiologic Components

Atrophies. Atrophy is tissue involution, the result of interference with the integrity *of its cellular constituents. The integrity of* a cell and consequently the tissue which it composes are dependent upon its innervation, circulation and the condition of its internal machinery, that is, its cytoplasm. Any or all of these may be influenced by trauma.

Atrophies, the result of trauma, are usually of a *local* or delineated character, their extent depending upon the type and the severity of the injury. Though a tissue as such may not be actually destroyed by trauma, its cellular architecture and its nervous or circulatory integrity may be so affected as to undergo gradual but definite changes leading to atrophy of the part. Cells severely traumatized undergo eventual liquidation. Coincidentally, nature makes the only attempt at repair she knows, and that is to replace the lost tissue by fibrous tissue. The liquidation of the severely traumatized cells plus their replacement by fibrous tissue leads to shrinkage of the part (Fig. 26).

The most vulnerable of all tissue to trauma is fat. Consequently, a large number of defects which come to the attention *of the plastic surgeon are such as result* from the loss of fatty tissue. If the trauma has been severe enough to affect the entire thickness of subcutaneous fat, this fat, after undergoing *liquidation, may lead to adhesion* of the overlying skin to the underlying structures such as fascia, tendon, muscle or bone, and a depression defect will ensue. Such *depression defects* are always

PLASTIC DIAGNOSIS

SURGICAL

TISSUE ABERRATIONS
(Diagnostic Differentials)

- Voids
  - Total
  - Partial
  - Relative
    - Cicatricial
    - Atrophic
    - Aplastic
    - Dystrophic
    - *Et cetera*
- Derangements
  - Segmental
    - Distortion
      - Locational
      - Cicatricial
    - Displacement
      - Accidental
      - Pressure
    - Misplacement
      - Surgical
      - Habitual
      - Et cetera
  - General
    - Distortion
    - Displacement
    - Misplacement
- Excesses
  - True
    - Virginal Hypertrophy
    - Endocrine
    - Callus
    - Polymeria
    - *Hypertrophies in general*
  - False
    - *Org. Hematoma*
    - Lymphedema
    - Paralyses
    - Aneurysms
    - Elephantiasis
    - Misplacements
    - Tumors
    - *Et cetera*

(A) TRAUMATIC
(B) CONGENITAL
(C) *NEOPLASTIC*
(D) ENDOCRINE & MISCELLANEOUS

CHART 2

scarless because the skin remains unbroken

The gradient of vulnerability of tissues to trauma depends upon many factors age sex *the nature of the offending agent* the severity of the insult, the pretraumatic condition of the tissue, the temperature of the part, its position and relationship to other tissues, as well as the general condition of the patient

All tissues affected by trauma nevertheless undergo the same basic experiences of cellular insult, edema interference with circulation disturbances of nutrition, shrinkage, and eventual dissolution and death with final substitution by fibrous tissue This applies to such controlled and minimal *forms of trauma as the needle puncture and* the surgical incision The cells in the direct line of the cut suffer immediate destruction and death, but by virtue of their loss the local cellular mosaic of whole groups of cells *suffers the consequences of the event* in gradual atrophy and disappearance for a distance and to an extent parallel with the nature of the cut With the liquidation of the destroyed cells and the eventual disappearance of the atrophic masses fibrous tissue replaces the loss These phenomena are the basic determinants of the character of the final defect

Wherefore in the closure of a surgical incision these unavoidable consequences of surgical trauma must be compensated for by meticulous apposition and a certain amount of overcorrection of the normal position of the tissues in order that the resulting repair will eventuate in a scar defect as minimal and innocent as possible

Even the closure of a surgical wound is a form of trauma which may lead to atrophy This is particularly evident in closures where the size of the needle and the suture material is out of proportion to the defect or the type of tissue, where the needling is

Fig. 27. Aplastic hemiatrophy (congenital) involving middle and lower third of face. Note flatness of cheek. Mandible was very thin. Zygoma and malar were of normal shape and size.

unkind or where the sutures are tied so tightly that they interfere with the innervation or blood supply of the incision and hence result in atrophy of the units of tissue included within the sutures. This leads to an exaggeration of the consequences of unavoidable surgical trauma and finally to a defect necessitating secondary plastic revision.

Atrophy due to intrinsic trauma, such as may result from pressure of accumulated fluid, gas, organized hemorrhage or tumor, will not be discussed here, as its treatment more properly belongs to other branches of surgery. There are outstanding exceptions. These will be discussed in the logical chapters.

Aplasia. Tissue void due to aplasia is usually a congenital condition based on some neurotrophic disturbance, in contrast with atrophy, which is more usually of traumatic origin and of a neurocirculatory nature. An aplastic tissue void is nevertheless of frequent interest to the plastic surgeon. It is not impossible in certain instances that aplasia may be due to some form of intra uterine trauma. At any rate it is a condition marked by a lack of proper original development rather than a regression of normal tissue as is the case in atrophy (Fig. 27).

An example of an aplastic condition occasionally seen is aplasia cranii, which is a congenital defect, the result of incomplete ossification of the cranial bones. The individual has to avoid the most trivial injuries to the skull because they may result in brain damage. In such a condition it is necessary to reinforce the cranial vault by means of cartilage, bone or Tantalum implants. Another aplastic condition is congenital facial hemiatrophy. Others will be discussed in Section III (Chap. 30).

Tissue Absence. The most notable cases of tissue void are those due to actual absence of tissue. This may be congenital, traumatic or the result of a lesion. Foremost among the last are voids due to epitheliomas, ulcers and carcinomas. Traumatic absence of tissue arises out of incisions, excisions, burns, lacerations, bites, gunshot wounds and amputating scar formation. Tissue void due to congenital reasons is represented by clefts, hernias, anomalies, malformations and intra uterine amputations.

Whatever the cause, a tissue void properly belongs in the realm of plastic surgery. The important thing in the determination of procedure, especially in congenital defects, is to make certain that an actual absence of tissue exists. Whereas in traumatic defects or those following lesions of one type or another the tissue lack is quite obvious and easily determined, in congenital defects this is not always true. For example, in the ordinary harelip there is no actual lack of tissue but rather a false placement or displacement of tissue.

Rarely there may even be a tissue excess There is always an associated tissue derangement The problem in these conditions is one of proper geometric replacement and anatomic apposition of tissues present

It is therefore obvious that in the diagnosis of a tissue aberration adequate focal examination be made in order to determine whether there is actual lack of tissue and if so what is its type Where an actual void exists it must be supplanted in some manner by tissue of the same or morphologically related ilk Where the defect is due to atrophy only a part of the tissue may be necessary to be supplied often only for the sake of form or appearance Where such a defect does not interfere with the function of the part the supplementary tissue does not necessarily have to be of the same kind Finally where an unusual or irreparable tissue void exists a prosthesis may be the only solution

TISSUE DERANGEMENTS

General

Tissue derangements whether of a segmental or general extent may be subdivided into distortion displacement or misplacement On the other hand a derangement can be a combination of the foregoing that is a displacement and a distortion or a distortion and a misplacement The repair of a tissue displacement involves simple replacement but where it is combined with distortion it often means excision of scar tissue and revision of the distortion before replacement is allowable or possible (Fig 28)

The nature and the degree of the derangements will depend upon the nature and the degree of the cause This may be augmented by age sex and general condition It may be further aggravated by injudicious treatments or surgery thus Making a monstrosity out of a deformity (Blair)

The various types of derangements may be of traumatic congenital or neoplastic origin The most frequent etiologic agent is trauma One basic difference exists between congenital and traumatic tissue derangements In the former there is frequently sufficient tissue present for an adequate repair and little or no scarring In the traumatic type although there is seemingly enough tissue present or the derangement may even give the impression that there is too much tissue present one must not be deceived by appearances The two factors always present in the latter to some degree are scar formation and collateral atrophy In other words the factor of distortion is more prominent in traumatic than in congenital derangements As a result after the scar tissue is excised and the deranged tissues mobilized for correction it will be found that an inadequate amount of material is left with which to make the correction

As indicated heretofore under Surgical Differentials it is an error of omission on the part of the student in plastic surgery to seek only in a tissue aberration a void a derangement or an excess Most tissue aberrations—particularly the traumatic type—are a combination of these tissue differentials In other words though a defect may be essentially a void some part of it is usually affected with a certain amount of tissue derangement While the over all picture of a condition may appear to be essentially a tissue excess it almost always is associated with some degree of tissue derangement

Etiologic Components

Pressure Tissue derangements resulting from pressure are of several types diastases depressions creases folds inclusions asymmetries scolioses and dislocations

Frequently the types resulting from pressure are histologically complex That is they involve not only skin but also subcutaneous tissue and underlying supporting tissue as well Proper evaluation of these types necessitates laboratory investigation

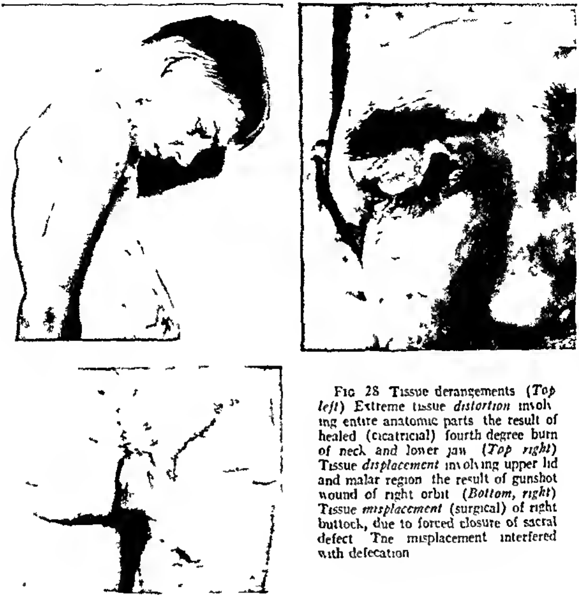


Fig 28 Tissue derangements (*Top left*) Extreme tissue *distortion* involving entire anatomic parts the result of healed (cicatricial) fourth degree burn of neck and lower jaw (*Top right*) Tissue *displacement* involving upper lid and malar region the result of gunshot wound of right orbit (*Bottom, right*) Tissue *misplacement* (surgical) of right buttock, due to forced closure of sacral defect The misplacement interfered with defecation

the use of X rays or even biopsy to determine the extent of the defect in depth Pressure derangements never should be attacked surgically until one has adequate knowledge of the condition of the underlying tissues It is not uncommon in old healed burns around the mandible to find that the pressure from a tough almost calloushike scar overlying the bone has produced such change in the shape or the structure of the bone that simple excision or eradication of the scar with ordinary apposition of the collateral soft tissues will prove to be an inadequate remediable measure The same holds true for pressure trauma due to casts shoes prostheses trusses etc (Fig 29)

Dystrophy Tissue derangements due to dystrophy are evidenced by ptoses depressions eversions and asymmetries These are usually more extensive than simple distortions or displacements and call for a thorough investigation of the patient's general condition Proper surgical correction in these cases necessitates a minute analysis of the function of the part, its circulation

and innervation The correction of these conditions may involve excision of considerable tissue therefore, it is important to see that function is in no way compromised Accurate anatomic dissection is necessary with realignment and meticulous apposition of the deeper tissues in order to conserve or improve function Therefore great care must be exercised in the diagnosis of every adjacent anatomic structure which enters into the dystrophy

A homely illustration of this type of condition is the painless but obvious bunion One should not hesitate to remove such a distortion though it is essentially a cosmetic procedure provided it is not done without due consideration to the function of the part

Other conditions which may be included under this heading of particular interest to the plastic surgeon as well as to the oral surgeon are the various asymmetries of the face resulting from abnormal facial growth patterns maldevelopments of facial bones leading to disturbance of muscle balance pseudo arthroses mandibular maltrusions and deviations of tooth development Surgical evaluation of these conditions is frequently difficult because of the complex interrelations of the various parts and their influence upon one another as well as upon function and form Hence adequate surgical therapeusis in many of these conditions is still an unsettled problem In general it may be said that diagnosis in this field should have for its aim the resolution of the functional implications of the derangement so that whatever surgical treatment is decided upon will meet the prerequisites of adequate usefulness as well as appearance (Fig 30)

Paralyses Tissue derangement the result of paralysis may result in depressions diastases ptoses folds and asymmetries The proper correction of these conditions involves first of all an adequate neurologic and functional diagnosis *For there is* always the hope, if not the possibility that

Fig 29 Pressure derangement of tissues of left elbow Patient wore a plaster of Paris splint with pressure on elbow until necrosis and sloughing of tissue resulted as shown

some type of neurorrhaphy or nerve transfer may be possible in order to remove the underlying cause of the tissue distortion Where this is not possible the defect must be visualized from the standpoint of static as well as functional appearance Any corrective measure decided upon must be a compromise between the appearance of the individual when the affected part is at rest and when the contralateral part or its anatomic mate is functioning Without proper evaluation of all of the factors involved in the paralysis a random correction may prove to be a shotgun prescription

Where neurorrhaphy is considered in derangements due to paralysis serious thought should be given to some type of complimentary interim or plastic procedure which will support the afflicted tissues until nerve regeneration occurs If this is not done the paralyzed tissues may atrophy before complete nerve regeneration takes place to a

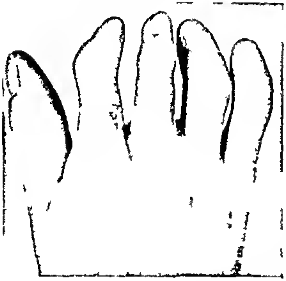


FIG 30 Dystrophic tissue derangement (*Top left*) Dorsal view of web hand of adult with resultant tissue dystrophy (*Top right*) Bone and joint changes of dystrophic hand

(*Bottom*) Two years postoperative Note improvement in joint alignment following surgery upon soft tissues only This illustrates necessity for reconstruction of web hands early in life to avoid permanent and usually irremediable joint involvement as shown here Finally there is no hope of further development of the digits at this late date (patient's age is 42 years) Note normal size of thumb and length of other fingers

point where function is irretrievable because the muscles are gone when innervation is completed

The outstanding example of paralytic derangement is the relatively common facial paralysis In determining the best type of correction the surgeon must make a thorough investigation of the origin and the clinical course of the case He must ascertain the point at which the nerve has been severed or destroyed One must know the cause of the paralysis This will help to determine which of the several procedures available for its correction is to be applied

A discussion of these types will be found in Chapter 30

Tumors Tumors can produce tissue derangement essentially by distortion and displacement Tumors are usually evidenced by elevations diastases ptoses eversions exclusions and asymmetries Not to detect the underlying cause in such defects prior to operation is to commit an error which may lead to disaster To attempt correction of a derangement due to an underlying aneurysm granuloma or neoplasm is to walk into serious trouble All tissue defects which are not obviously congenital or due

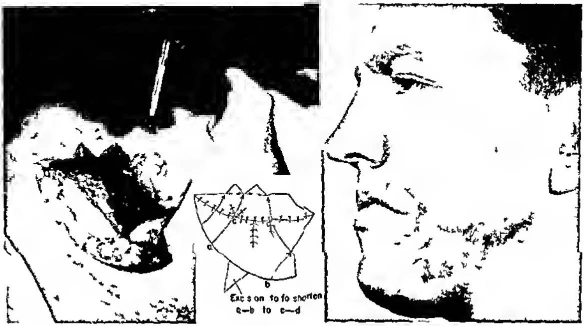


FIG 31 Planned excision with afore thought of reconstruction (*Top left*) Same case as preoperative Figure 19 (basal cell carcinoma of left jaw involving soft tissues) Note planned geometric excision Elongated white area is the mandible Inset shows preoperative plan of contemplated closure Arrows indicate direction in which tissues were advanced or shifted to accomplish closure The latter is represented by the cross hatched horizontal and short vertical lines Note wedge-shaped section which had to be excised from line a b as shown in sketch so as to make it equal to straight line c d (See Chap 21 Surgical geometrics) (*Top right*) Note closure without distortion of mouth or cheek

(*Bottom*) Front view (functional) There is a minimal amount of tissue tension through left melo nasal crease but only when patient opens his mouth widely as shown The case illustrated certain advantages of careful geometric planning of excision such as—a one stage operation minimal hospitalization unnecessary grafting low tissue cost etc

Fig 32 An illustration of extensive traumatic derangement of tissues due to loss of mandibular symphysis Note collapsed position of mandible ectropion of lower lip scarring and displacement of soft tissues over lower jaw and muscle imbalance extending to paranasal musculature

to trauma always should include the consideration of some underlying neoplastic etiology It is better to err on the side of doing an eventually unnecessary biopsy than to find oneself faced with a situation which may necessitate a radical resection of the part due to the presence of a deep hemangioma lymphangioma or sarcoma

Where a tumor exists it is best to concentrate on the eradication of the neoplasm with secondary but definite consideration for the cosmetic results of the operation Hence at the time of excision of the growth it is good policy to replace immediately severed tissues in a normal position as possible to make subsequent repair easier and at a lowered tissue cost (Fig 31)

Accidental Trauma The greatest etiologic factor in the production of tissue derangement is accidental trauma It is the result of automobile accidents industrial injuries injudicious first aid or poor original repair (see Chap 15 Original Repair) Where the general condition of a patient following an automobile accident or industrial injury is not equal to adequate repair it is far better to defer the latter than to do a makeshift closure and create a tissue distortion which may necessitate a series of plastic corrections otherwise avoidable A more detailed discussion of the subject will be found in the Chapter 15 Original Repair

The character of the defect is usually due to the type and the severity of the trauma The tissues primarily responsible for derangements following injury are the muscular structures and the subcutaneous fat Displacement fractures causing muscle imbalance loss of subcutaneous tissue and skin usually lead to the most obvious types of tissue derangements (Fig 32)

After estimating the amount of tissue which has been lost the next step is to determine how much of the various tissues may be available in the vicinity of the defect for repair The evaluation of the collateral tissues as well as the defect needs considerable experience and mature judgment Such differential evaluation is not always a simple matter However if a thorough systematic examination of the part is made as outlined in Chapter 6 Physical Examination reliable knowledge of tissue loss usually will be forthcoming

Meticulous physical examination of every part of the defect in both static and active or functional state plus accurate measurements with tape and dividers are of great help Comparison of the defective part with its contralateral mate is good practice It may be necessary to resort to certain laboratory aids such as moulage and X ray examination for final evaluation

In the case of a gross cheek defect it is

good policy to locate the mouth of the parotid duct and inject it with opaque substance for roentgenologic purposes X ray examinations in defects where any injury to the underlying osseous or other supporting structures is suspected always should be done The conventional manner of taking roentgenograms in these conditions may not be adequate The surgeon should consult with the roentgenologist concerning other than routine positions necessary in any given case

Determining the extent of the scarring and the timbre of the collateral tissues may not be possible from physical examination alone Frequently this must await elucidation during surgery A judiciously applied and carefully calculated biopsy of one or more parts of the defect may give one the necessary information Biopsy evaluation of traumatized tissues is not sufficiently used its value has been stressed elsewhere in the text

TISSUE EXCESS

General

Tissue excesses may be true or false depending upon whether they are hypertrophies or hyperplasias on the one hand or neoplasms misplacements or displacements on the other Edemas naturally are false excesses Insofar as pathology is not prepared to differentiate basically between hypertrophy and hyperplasia from the surgeon s standpoint the two may be treated under the same heading

Etiologic Components

False Excesses Trauma Excesses due to tissue displacement or misplacement are usually the result of careless surgery trauma or paralysis but they may be congenital The greatest proportion of misplacements are of traumatic or surgical origin In the original repair of an extensive laceration if normal replacement of tissue is not accomplished focal excess will result

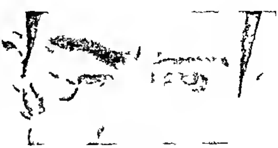


Fig 33 Tissue *excess* in outer third of lower lid due to surgical *misplacement* At time of original repair the avulsed lower lid not recognized as such was sutured out of position resulting in superfluousness at outer canthus Recognition of the true nature and quality of tissue excess is imperative to intelligent reconstruction

leading to defective appearance and also to disturance of function (Fig 35)

Neoplasia Tissue excesses due to neoplastic growth frequently come to the attention of the plastic surgeon This is particularly true in conditions involving exposed parts of the body such as nevus lipomatodes and other forms of nevi malignant hemangiomas lipomas fibromas epidermal carcinoma congenital warts and a host of others (Fig 34) Where such lesions have resulted in distortion of collateral tissue or destruction of deep tissue necessary to normal function their eradication in a manner which promises restoration of adequate appearance as well as function is quite properly the field of the plastic surgeon (Plate 1)

Unless the neoplasm is malignant ablation of the growth must be carried out in a manner consistent with the form and the function of the part This applies particularly to the face breasts genito urinary organs nose ears mouth jaws and hands The unplanned rampant or even careless excision or amputation of an unsightly mark or growth with only after thought as to form and function of a part is inconsistent with good surgery The principles and the practices of plastic surgery stand in good stead in this field and for that

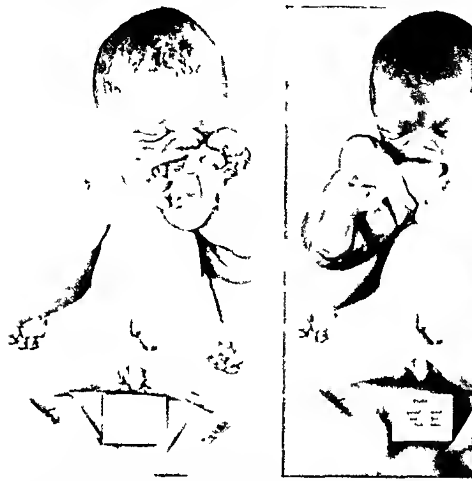


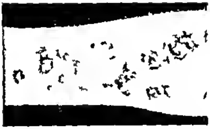
FIG 34 Tissue excess due to congenital causes as exemplified by above Epignathi a parasitic monster attached to jaw of autosite fetus (Dr Bernhard Steinberg) Although this is an extreme example of intraoral pathology minor conditions of like origin and location may become problems for reconstruction

reason if no other should be the property of all surgeons

True Excesses ANOMALIES Many anomalous conditions which do not involve the basic usefulness of an anatomic part come to the attention of the plastic surgeon and constitute a prominent source of material They range from the more common forms of polymeria to very complex tissue excesses (Fig 34) Their removal is always associated with some need for local reconstruction whose degree is more or less determined by the neuromuscular involvement of the part and by the presence or the absence of other anatomic elements necessary for reconstruction Double noses lips hands multiple breasts etc are a few examples of tissue excess Their management is discussed in the appropriate chapters

ENDOCRINE Superfluous tissue growth as a result of endocrine disturbance when it involves function comfort or appearance of a patient falls into the domain of the plastic surgeon These conditions are for the most part made up of asymmetries adiposities acromegalies hyperplasias localized cutaneous changes and others beyond the normal remedial control of the internist or general surgeon All such conditions need special consideration and a diagnostic perspective Though the possibility of ultimate cure in many of these conditions is

PLATE I



False tissue excess Pathologic diagnosis is neoplasia (carcino matous) of congenital pigmented nevus of the right lower extremity The patient s age is 36 years the duration of neoplasia is 3 months This was accompanied by minimal cutaneous edema of the entire lower extremity There were no metastases clinically or microscopi cally For extent of nevus and surgical therapeusis see Plate 17

obviously beyond the scope of the plastic surgeon telling relief can be brought to the patient by judicious palliative correction or reconstruction of the afflicted part In principle this is parallel with certain therapeutic procedures for advanced inoperable carcinoma (Fig 35)

It is in these cases where the surgery of form apropos its influence upon function merits serious consideration When for instance the angles of the mandibles in leontiasis ossea become so prominent as to make it difficult for the patient to open his mouth it is quite proper that excisions *should be planned and executed* so as to improve the patient s ability to open his mouth yet the surgery should be kept consistent with good appearance and function

Virginal hypertrophy of the breasts is another example in point The majority of these breasts although occurring in young women are functionally impotent Yet by virtue of their unusually large size and amazing weight they interfere with efficient function of the individual as a whole and at times lead to invalidism particularly during the summer months

FIG 35 Generalized bodily tissue excess the result of endocrine causes

All conditions falling in the category of tissue excess except those due to trauma have one thing in common from the standpoint of diagnosis in plastic surgery An accurate estimate must be made of the amount of tissue actually superfluous and destined for excision in order that the remainder after reconstruction shall adequately serve not only appearance but also normal function where possible Only thorough understanding of the deformity will make it possible to plan surgical procedures adequate in both respects

SEGMENTAL ANALYSIS

A tissue aberration as indicated heretofore may be a simple one consisting of a void a derangement or an excess or it may be a complex one consisting of two or more of the above mentioned components In other words one part or segment of a defect may be essentially a void whereas another part may be truly a gross derangement or even appear to be crowded with excess tissue Therefore each and every defect must be segmentally analyzed in order that proper replacement and adequate overall correction may result

This issue is not infrequently met with in defects of the cheek (Fig 36) What at first glance would seem to be only a rather simple healed laceration upon closer analysis may prove to be a complex distortion with misalignment of the two sides of the defect resulting in asymmetry and extensive fibrosis The latter is usually the product of abnormal tissue tension To proceed by the mere and haphazard excision of the

Fig 36 Segmental analysis (*Left*) Value of segmental analysis At first glance the obviousness of depression deformity of cheek may overshadow displacement of the outer canthus upward and the outer third of the lower lid inward and upward Also note lateral displacement of outer extremity of eyebrow and derangement of upper lid (*Right*) Result after proper segmental evaluation and repair Note multiple Z closure of cheek with exteriorization of outer canthus and repositioning of upper lid and lower lid tissues

scar tissue and direct re apposition of the lips of the surgical wound without accurate analysis of where and how the various parts of the defect belonged originally is to substitute one type of distortion for another If in addition there is present a lack of subcutaneous tissue making it a complex defect such simple excision of a scar and random apposition of the surgical wound can only result in the substitution of a surgical for a traumatic defect For methods of scar excision and plan of repair see Chapter 18 Surgery of Scars

The proper replacement of deranged tissue is a prerequisite of adequate plastic repair This may be difficult enough in the original repair but can be doubly difficult in late repair especially where the tissues have been conditioned by scar and time to assume new and strange form Only proper and thorough segmental analysis of a derangement will prevent the substitution of one deformity for another

Where the deformity of a cheek is extensive it may be found that one part of it is essentially a tissue void whereas another part may be defective due to tissue derangement and still a third portion of the same defect may be entirely a tissue excess The last may be due to tissue misplacement keloid or hypertrophy depending upon the age of the individual the method of original repair the age of the deformity the effects of gravity upon the surrounding tissues and other factors influencing form and symmetry

Fig 37 Complex injury to right cheek involving all three surgical differentials void derangement and excess The posterior third of the defect over the angle of the mandible is a tissue void that of the cheek proper a tissue derangement the mass of tissue in the corner of the mouth is a portion of upper lip surgically misplaced and therefore a tissue excess in that region The entire upper lip is rotated to the right and upward and is sutured in the maxillary region an example of surgical misplacement of tissue The same applies to the right ala Such step-by step and item by item analysis is imperative to adequate repair

By adequate segmental evaluation of a defect it is frequently possible to design a satisfactory reconstruction through borrowing of tissue from that part of the defect where an excess exists and shifting the tissue to the part of the deformity where there is an actual lack The revision of deranged tissue in itself often supplies a surprising amount of material for reconstruction of the defect as a whole Such tissue derangements are common in defects where considerable scarring is a part of the picture

The mechanism of development of such complex defects may be stated succinctly as follows An individual sustains a major injury resulting in a prominent tissue void The surgeon due to haste zeal or incompetence at the time of original repair forces a closure without due regard to tissue alignment This results in the crowding of available tissue into abnormal position and form producing an excess in locals where normally less tissue is found After healing takes place the scar tissue begins to contract and further distorts already (surgically) misplaced tissues This establishes complete derangement of the involved part to the point of functional aberration The ultimate clinical result is a defect in the category of deformity (Fig 37)

The meticulous excision of scar tissue plus adequate dissection and repositioning of misplaced tissues plus the advantage which accrues from their elasticity when adequately mobilized supplies much of the material available in corrective plastic procedures Reconstructions based on the foregoing thesis are the most physiologic Meticulous identification of tissues and evaluation of their potentialities is not only imperative but needs considerable imagination and experience Notwithstanding adequate differential diagnosis of tissue identity, quality and quantity both before and during operation is the only guarantee to good repair The first materially simplifies the surgical plan in that complete knowledge of the deformity as well as of the collateral tissues frequently results in a one or two stage operation Otherwise it may lead to transfer or importation of tissues extraneous to the defect which only makes the reconstruction more involved and more prolonged This may result in tissue loss and tissue waste out of proportion to actual tissue need The second materially simplifies the timing of postoperative treatment and assures better functional results

The entire mental process of diagnosis in plastic surgery must be attuned to the proposition that whereas tissue void means tissue cost tissue derangement means tissue gain if recognized and finally that tissue excess in one part of a defect does not necessarily mean excision but replacement to its point of origin With proper application of this perspective in diagnosis a more simple surgical repair will almost invariably be the result Simplicity in surgery means physiologic surgery and functional results

It is doubtful whether overemphasis of adequate diagnosis in reconstructive surgery can be committed Wherefore a certain degree of re emphasis of terms and fundamentals in diagnosis has been deliberately effected in this chapter for pedagogical reasons

BIBLIOGRAPHY

Burman M Kinetic disabilities of the hand and their classification A study in balance and imbalance of the hand muscles Am J Surg (N S) 61 No 2 1943

Doherty J A Practical points in the diagnosis and treatment of fractures of the jaws Surg Gynec & Obst 72 96 1941

Foot N C Pathology in Surgery Philadelphia Lippincott 1945

——— Identification of Tumors Philadelphia Lippincott 1948

Gillies H D Plastic Surgery of the Face Oxford Med Pub 1920

Jamison H W A simple accurate fluoroscopic method of foreign body localization Radiology 47 397 1946

Lexer E Weiderherstellungs Chirurgie Leipzig Barth 1920 p 360

McBride E D Disability Evaluation Philadelphia Lippincott 1945
MacBryde C M Signs and Symptoms Their Clinical Interpretation Philadelphia Lippincott 194
McClintock L A and Friedman M M Utilization of antibody for the localization of metals and dyes in the tissues preliminary report Am J Roentgenol 54 No 6 1945
Mannheimer B Visualization of foreign bodies of low radio-opacity Brit J Radiol 19 No 227 1946
Pollock L J The relation of the nervous system to blood pressure Chicago Med Bull 50 755 1948
Reddy D G and Thangavelu M A new technique in sternal puncture The Indian M Gaz 80 No 10 1945
Schulz M D and Weinberger D The Sialogram in the Diagnosis of Swelling about the Salivary Glands (Surg Clin of North America Mass Gen Hosp No) Philadelphia and London Saunders 194
Timofeyevski A D Tumor origin as determined by tissue culture Am Rev Soviet Med 4 No 2 1946

10

Planning the Treatment

Meticulous planning of the treatment in minutest detail is an imperative in plastic surgery The results of a corrective surgical procedure are to a large degree evidences of preoperative planning

Sound planning rests upon complete evaluation of all records and material which may have bearing upon the case This includes the history the general physical examination the particular examination the evaluation of such aids as moulage photography X ray and laboratory material as well as the self evaluation of the surgeon

Consistent results are never the consequence of chance or happening they are the fruits of a well laid and precisely executed plan Upon close examination of any plan of treatment one can usually detect at every turn the personality vitality integrity and rationality as well as the knowledge of the surgeon A well laid plan not only gives inner confidence to the surgeon himself but also radiates as much to his patients Most important of all it gives consistently good results

THE SURGEON ARCHITECT

Plans do not happen they are conceived Their nature and adequacy depend upon the imagination and the experience of the surgeon

Over and above the necessity for the surgeon to be a man of good physical emotional and psychological integrity in this specialty he must also be an individual of certain gifts and imagination In the words of Blair There is necessarily something approaching a gift back of its (plastic surgery) higher flights which cannot artificially be called into being and without a natural flare the work cannot go beyond standardized mediocrity Given the combination of ability and the will to do both quality and facility of production can be stepped up indefinitely by training and circumstance *

Like the sculptor the mathematician the artist or the musician the surgeon is a human personality of distinctive and individual qualities For the plastic surgeon not to have the benefit of a sense of proportion and symmetry a certain artistic flair and a zeal for perfection in smallest detail stamps him as only an artisan rather than an artist All his work will bear the mark of a patternmaker rather than the mark of surgical artistry His reconstruction or corrections will produce noses all of which look alike his harelips will be only a flap over the upper teeth and repairs in general will be only patchwork

One can learn how to cut a skin graft or prepare a pedicle flap in a very short period of time but to learn the many things which can be done with it the manner of turning them to form and symmetry is a quality more difficult It takes a cunning imagination and love of the work if these qualities are absent difficulties are created for both the master and the pupil

THE PATIENT

Any adequate plan of treatment always must consider the patient as an organic whole and a functional unit No plan is ever adequate without taking into consideration

* Blair V P Surgery specialty urgery and plastic surgery Surg Gynec & Obst 62 895 1936

the patient's personality as well as his physical welfare. No matter how well chosen a surgical procedure may be, it never can benefit a patient whose personality is antagonistic or prejudicial to his own welfare. To disregard this principle is to court psychological disaster in spite of surgical success. Such a complication is as unwelcome and yet as avoidable as a pulmonary abscess following a tonsillectomy (see Chap. 3, "Psychological Considerations").

Next is the proper appraisal of the patient's general physical condition. It is particularly necessary where general anesthesia has to be employed or where the correction of defects may prove to be a prolonged surgical relay, as in war injuries, or where the general condition might prove to be contraindicative to surgery. In the last category belong cardiorenal disease, hemorrhagic diatheses, pregnancy, blood dyscrasias, diabetes, tuberculosis or recurring generalized cutaneous conditions, such as psoriasis. Their relationship to healing and esthetic results has been more fully treated elsewhere in this text.

It is perfectly proper that patients be apprized of the fact that all operations carry with them some risk even under the best conditions. Insofar as the average plastic procedure deals with a local defect, the risk to the patient's life is negligible. Notwithstanding, a very important tissue risk exists. The meaning and the import of tissue risk in plastic surgery soon become evident if one attempts only corrections of a few "minor" defects of the ear, a poorly repaired harelip, or the revision of a vertical scar of the suprasternal notch so frequently found after tracheotomy. Repeated attempts at the ablation of such apparently minor defects without thorough knowledge of plastic procedures soon dissipates the attitude of "little risk and minor operation." When such operations fail, they result in considerable tissue cost and economic loss.

The dramatization of the accomplishments of plastic surgery by the lay mind may leave the idea that corrective surgical procedures are some form of extraordinary simple surgery where the only risk is the failure of the attainment of esthetic perfection. This is unfortunate. Patients always must be apprized of the fact that corrective surgical procedures are never outside the pale of consequences or complications peculiar to all forms of surgery. It is wisdom and kindness from the very outset to inform the patient that all forms of surgery, plastic surgery not excepted, begin with an incision and end up with a scar. The only consolation the plastic surgeon can give his patient is that it may be possible to so place the scar as to make it as inconspicuous and as minimal as conditions and skill permit. The patient's hopes and expectations must at all times be determined by the surgeon's honest exposition of the realities which should be enumerated in every case and never left to the patient's imagination.

THE TISSUES

A corrective surgical procedure must always fit the individuality of a defect. The correction of the defect never should follow some preconceived, premeditated or habitual surgical fetish. It should be dictated by the condition and the kind of tissue comprising the defect and the quality of the tissues available for repair.

Tissue Vulnerability

Since surgery is a form of trauma, it follows that the more extensive or involved the defect, usually the more telling the surgical trauma incident to the correction. All tissue has a certain threshold of vulnerability. This vulnerability to trauma increases as that tissue is removed from its physiologic norm.

Scar tissue is the most vulnerable. All acquired defects heal in some degree by the deposition of scar tisue. Repair of such defects must begin with evaluation of the amount of scar tissue present. The ramification of the scar tissue will in itself dic

tate the degree of dissection necessary. This, to a large extent, determines the amount of unavoidable surgical trauma If the tissues comprising or surrounding the defect, or both, are grossly scarred, edematous, congested or atrophic, obviously the amount of surgical trauma they will stand is minimal If such a defect should indicate considerable dissection, it is better to divide the correction into several stages. This applies as well to the excision of scars Scars cannot always be excised in toto, either because of their size or because the quality of the surrounding tissue does not permit reliable closure

The threshold of vulnerability to trauma of tissues adjacent to a scarred defect is almost without exception lower than that of normal tissues Even though not edematous, congested or obviously atrophic, they nevertheless are afflicted with certain cellular pathologies and degrees of neurocirculatory disturbance, which makes surgical trauma more telling in its effect upon healing than is true when incisions are made into normal tissues The actual condition of the tissues adjacent to a defect depends upon many factors, such as the time which has elapsed since the injury, the age of the patient, the quality of the original repair, the presence or the absence of foreign bodies, the size of the defect, the amount of scar tissue present, and the type of tissue involved When any clinical evidences of neurocirculatory or metabolic disturbance of tissue is evident, these must be corrected preoperatively by physiotherapy, time and other means

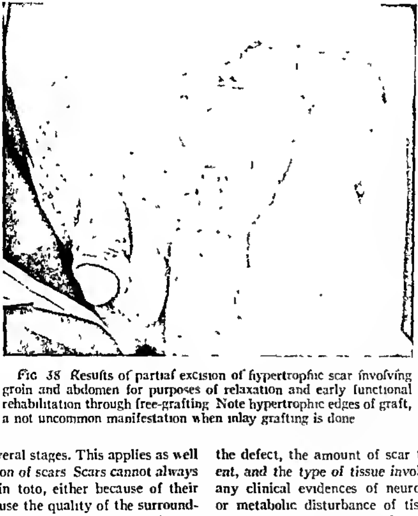


FIG 38 Results of partial excision of hypertrophic scar involving groin and abdomen for purposes of relaxation and early functional rehabilitation through free-grafting Note hypertrophic edges of graft, a not uncommon manifestation when inlay grafting is done

At times an operation as such can help to alleviate the abnormal tissue condition. Surgery can augment directly the circulation of a part This is particularly true of procedures designed to relieve tissue tension by at least partial scar excision with free graft-

ing of the resulting defect (Fig 38) multiple Z plasties or softening of scars by various means all tending toward collateral tissue relaxation Further discussion of this subject is reserved for Chapter 18 Surgery of Scars

Tissue risk is present in the repair of congenital defects as well as in the correction of traumatic defects although not in the same degree The degree of difference lies in the fact that in the traumatic defect there is much more pathologic physiology extant in tissues adjacent to defects as compared with congenital conditions Consequently the influence of surgical trauma upon such tissues is more nearly akin to that of normal tissue Hence in the correction of congenital deformities the surgeon can better rely upon the ordinary clinical signs of tissue integrity before surgery and the signs of tissue trauma during operation (For the latter see Chap 12 Surgical Process)

Tissue Timbre

Certain general tissue qualities may be used as clinical indices of tissue timbre In general thick skins do not heal as readily and as well as thin skins Dry skins give poorer scars or even keloids as compared with so called moist skins The more elastic the skin the less it will suffer from surgical trauma Skin normally overlying a large amount of adipose tissue will stand relatively more surgical abuse When the body as a whole suffers with over deposition of fatty tissue the skin in general will respond more acutely to trauma The pinker the skin the more resistant it is to injury whereas the more bluish skins are less resistant to injury This in a measure is due to the fact that the bluish skin usually has a more extensive venous circulation because the vein is more easily injured than the artery such skins are more vulnerable In fact the survival of all traumatized tissue is far more dependent in the first 72 hours upon the integrity of its venous circulation than upon its arterial supply unless the arterial supply is completely cut off Skins with a large amount of epidermis are less reliable in their healing powers as compared with skins where the derma is the predominant constituent It is not uncommon to see the derma in an incised skin heal completely whereas the epidermis will stay separated for days or even weeks Occasionally the epidermis in such skins will slough around the incision leaving an exposed pink derma and only days later will the former regenerate from the sides or the glands contained within the derma This is not uncommonly seen in incisions or lesions of the palm of the hand the sole of the foot or the back This complication is notorious in electrical burns of the skin when rigid asepsis is neglected

Certain dermatologic conditions indicate poor tissue timbre If the patient is afflicted with pimples boils carbuncles eczemas excoriations psoriasis or any other skin lesions it is well to assume that the quality of his tissues is inferior at least for the time being In such cases corrective surgery should be postponed

Any plan of treatment which does not embody within it a careful inventory of all the tissues which may come into the zone of operation is not a sound plan and will almost always lead to disappointments postoperatively

SPLINTING

Provision for adequate postoperative splinting of soft tissues is one of the most important phases of good planning This is a basic imperative sometimes difficult to master in plastic surgery The difficulties arise from the fact that soft tissues in contrast with bone are never rigid enough to be anchored or staged easily Whereas one bone fragment in some measure will splint another the opposite is usually true in soft tissues The latter when severed always retract Whereas soft tissues in themselves act more or less as a splint for a fractured

bone the reverse is not true in the same degree

The splinting of soft tissues of the face and those surrounding the bodily orifices presents a special problem Obviously general bodily functions must be maintained throughout the period of healing There fore the mechanical splinting of such soft tissues can only be exercised to a degree not interfering with respiration deglutition and some degree of mastication and excretion Many ingenious ways have been devised for splinting tissues about orifices of the already accomplished repair is necessary Otherwise shrinkage distortion due to postoperative fibrosis gravity and other factors is unavoidable This is especially true of reconstruction involving the jaws the orifices and the hands Splints designed for such purposes must not only maintain the integrity of the repair but also allow basic functions Interim splints of necessity must be completely accurate in their design and construction and are always among the most ingenious and difficult to make (Fig 39)

Many substances and materials have been

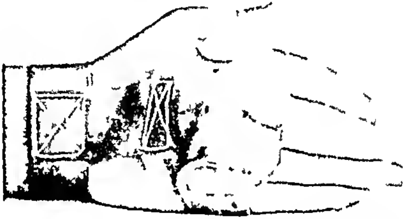


Fig 39 A type of extemporaneous interim splinting to protect soft tissue repair of dorsum of hand until bone grafting of metacarpals is permissible Attachment (bridge) between wristlet and dorsal coverage prevents overflexion and disturbance of repair

employed in making such splints Among these are acrylics tantalum gold vitallium silver ivory ticonium and others These are considered in Chapter 19 Splints and Splinting

Satisfactory splinting of soft tissues from both the anatomic as well as the physiologic standpoint must frequently be a compromise between the contoural and the mechanical difficulties of the part its position its specific function and the general welfare of the patient (see Chap 19)

Interim Splinting

Major defects of the human form cannot always be corrected in one surgical inning In gross injuries such as are common in war a dozen or more separate surgical procedures may be necessary In the interim between the surgical innings maintenance

CHOICE OF PROCEDURE

The factors which determine the adequacy of a procedure in corrective surgery are four the peculiarities of the case the ability and the experience of the surgeon the condition under which the procedure will have to be executed and the rationale of the procedure itself

The peculiarities of a case which influ

ence choice of procedure are age sex general condition extent of the defect availability of tissue for repair, ultimate tissue cost, and economic condition of the patient Examples of the foregoing are legion For instance it is generally conceded that a cleft palate operation is not advisable prior to the age of 18 months Again one would hardly think of borrowing tissue from the region of the breast in a young girl because of the probability of postoperative interference with the breast development It would be folly to plan an extended procedure at a time when little tissue is available for repair as is often the case in extensive burns In defects where there is great loss of bone as well as soft tissue the tissue cost in the repair of the condition might better be avoided by resorting to some form of appliance or prosthesis If the economic condition of the patient is such that a series of operations necessitating prolonged hospitalization should prove to be a drain upon the welfare of his family some other procedure or method of remedying the defect should be considered Wherefore procedures are usually spoken of as those of *choice* and those of *necessity*

Procedures of choice are such as can be dictated by the surgeon his conscience and the conditions of the case Procedures of necessity are such as are forced upon the surgeon by circumstance precarious condition of the patient severity of a defect or the uncompromising demands of a situation Foremost among such conditions is the very extensive and severe burn sometimes involving 50 per cent or more of the body Homografts may have to be used as a life saving measure although skin grafts taken from others are known never to survive for more than a few days to six months This does not apply in the case of identical twins

Finally there is a difference between a procedure of choice and a choice procedure The latter is the ideal procedure as it applies to a certain specific case The former is any one of several procedures which will accomplish an acceptable result in the same category of cases In other words a specific defect may be repaired by one surgeon with tissues collateral to it and by another with tissues from distant parts of the body in the form of a tube pedicle a flap or a free graft Both men may get satisfactory results The first is the choice procedure the second a procedure of choice The whole business is a matter of evaluation interpretation visualization imagination training experience and ingenuity—the marks of the expert surgeon

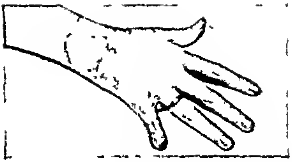
The surgeon should honestly evaluate his own ability He must never be tempted beyond his depth of experience He should heed the experiences of other surgeons with the procedure and should appraise his own technical ability as against the demands of the method

Most modern hospitals are equipped so that almost any standard corrective operation may be accomplished within their confines If one is forced to operate under conditions of poor lighting ventilation temperature assistance or asepsis major or protracted procedures should be guarded against It is not possible to meet the exacting demands of plastic surgery on a kitchen table

Once the surgeon has decided upon a procedure he should understand both its anatomic and physiologic implications The simplest procedure which will accomplish the desired result is usually the best The technical difficulties must be clearly visualized before the surgeon decides whether for him a particular procedure is a simple procedure

Not all procedures described in textbooks can be relied upon as anatomically and physiologically rational This is particularly true of operations described for the correction of major defects of the face or genital organs Some of these occasionally encountered in books of surgery are of a caliber which leaves doubt as to whether or not they are the result of operating room experience Finally consideration must be given

PLATE 2



Results of inadequate interim postoperative splinting of full thickness bracelet type skin graft The patient was allowed wrist flexion too soon after removal of sutures, hence the hypertrophic, hyperemic suture lines with fibrous tissue proliferation in the distal edge of an otherwise completely survived graft Note similar reaction about full thickness graft of the little finger, for the same reason For protection against such eventualities, see Figure 39

FIG 40 Late results (*Top left*) Condition of full thickness skin grafts 7 years postoperative applied to both insteps originally afflicted with almost symmetric pressure sores resulting from plaster casts Lower borders of grafted regions discernible by slight bronzing This occurred actually just outside the grafted areas (*Top right*) End results (6 years postoperative) of total reconstruction of heel Patient walked on it daily (*Bottom*) Plantar aspect Observe acute creasing where new heel meets sole This local is curiously the point of most frequent late trouble postoperatively due to creasing of skin incident to walking Excision of skin redundancy at this point (2 or 3 years after reconstruction) is a common necessity with most surgical heels (Since this photograph was taken patient has added another 5 years of usefulness to the heel)

as to the late results to be expected from the operation

LATE RESULTS

The planning of any surgical reconstruction should include consideration for its permanency What will be the quality of the functional as well as esthetic result obtained say two or three or even five years following the operation (Fig 40)? It is not at all uncommon to obtain what appears to be an acceptable result immediately after an operation and then experience dismay because the repair proves to be functionally or esthetically inadequate six months later The merits of a procedure as concerns permanency are basically anatomic and morphologic

There are of course procedures which by the very nature of the case must be pro tempore interventions This is always true in the revision of severe ear nose jaw genito-urinary and other defects in very young children A type of correction must often be made in the knowledge that with the growth of the child and the passing of time augmenting revisions or corrections will be necessary Such operations are done to avoid eventual tissue changes collateral to the defect or to lay an appropriate foundation for ultimate correction of the deformity later in life The parents of the child must be apprized of the facts in the case so that there is no misunderstanding later on

All the foregoing considerations are basic They must be kept in mind constantly and must be applied systematically in the adequate planning of an operation

BIBLIOGRAPHY

Blocker T G Principles of reconstruction of defects about the face Texas State J Med 42 526 194

Connolly F A Diagnosis and management for first forty-eight hours Nebraska M J 31 268 1946

Conway H Principles of plastic surgery in the treatment of malignant tumors of the face Surg Gynec & Obst 72 449 1942

Dixon C F and Benson R F Surgical management of large tumors of the neck Report of two unusual cases Am J Surg (N S) 69 No 3 1945

Figi F A Treatment of cancer of the larynx with emphasis on conservatism Ann Otol Rhin & Laryng 50 723 1941

Gordon S D The treatment of gunshot wounds of the face Bull Acad Med Toronto July 1945

Kazanjian V H Primary care of injuries of the face and jaws Surg Gynec & Obst 72 431 1941

Letterman G S Flexglas splints Their use in pedicle flap attachments Plast & Reconstruct Surg 3 553 1948

McClure R D and Lam C R Should the neck nodes be dissected in patients with carcinoma of the lip? Ann Surg 125 No 5 1947

Smith F Planning the reconstruction Surgery 15 1 1944

Speer E B Principles versus mechanisms in surgery Northwest Med 45 415 1946

Templeton L C Surgical preparation of the mouth for artificial restoration Am J Orthodontics 31 No 8 1945

11

Activation of the Surgical Plan

PREOPERATIVE MANAGEMENT

There is always the danger that the busy surgeon will become too much of an operator and too little of a doctor, too much of an artisan and too little of the scientist This is probably more true with the surgeon specialist than with the general surgeon Notwithstanding the adequate management of any case implies that the surgeon be responsible for everything which happens from the time the patient enters his office until the same patient is discharged as cured or improved

Adequate preoperative management means an over all system of care and caution Nothing just happens by itself It must be planned No one is better qualified than the surgeon himself to delineate the preoperative plan specifically indicated in a given case The precise plan of management of any one case is never the business of the intern or the nurse, although the execution of the plan may well be assigned to either or both, under proper supervision, since that is an indispensable factor in teaching

The patient should be made to understand that he too has certain responsibilities toward the success of the operation He should be informed of the type of operation being contemplated, as well as the risks and the limitations of the procedure He should have impressed upon him that certain conduct is demanded of him and that possibly certain inconveniences as to time, work and patience must be faced as unavoidable in the successful prosecution of the plan He must be psychologically prepared so that his co operation throughout the treatment will be a foregone conclusion He never must be left to wonder what is going to happen next and why In short the surgeon must take the patient or the family or both, into his confidence

Patient's General Condition

The general physical condition of the patient must be assured in the activation of the surgical blueprint No patient requiring extensive corrective surgery should be operated upon who is not in the best physical condition Much time can be lost because of it In this connection certain rules should be followed

No patient should be operated whose hemoglobin is less than 70 per cent or who gives a history of recurrent skin afflictions such as carbuncles or psoriasis or who has any chronic infections, such as a running ear, syphilis or extensive active bronchiectasis In this same category belong patients who have any form of blood dyscrasia low platelet count, diabetes, or who for some reason have suffered considerable loss of weight in the period immediately preceding the operation Such conditions entirely exclude plastic procedures or must be thoroughly controlled by general treatment before surgery

In operations upon the atria, such as the mouth, the nose, the ear or the vagina all communicating parts must be investigated for any pathology present, and any such pathology should be completely eradicated Prior to operations upon the jaws, a thorough and complete correction of suspicious dental conditions and other aspects of oral hygiene must be instituted

Vitamins and the Skin

The general timbre and condition of the skin is of particular consequence to the plastic surgeon. The important relationship of vitamins to the integrity of the skin is generally accepted. Vitamins are a part of a complete and adequate diet. Although they are essential, they cannot accomplish miracles. Vitamin therapy is pertinent only when the patient suffers with an actual vitamin deficiency. It may produce revealing results at such times.

Although moderate vitamin depletion may not cause any visible lesions, it can produce disturbances in the tissues, particularly the skin, which are of significance in the process of healing. Certain vitamins are of outstanding importance in this connection.

Patients suffering with a vitamin A deficiency show pathologic changes in the skin essentially due to epithelial metaplasia. The normal skin epithelium atrophies and is eventually replaced by the proliferating basal cells which ultimately become keratinized. The keratinized epithelium accumulates in the glands and the ducts of the skin and produces some of the gross pathologic features of the deficiency clinically. The metaplasia results in dryness, roughness and follicular eruptions. These may appear rather suddenly on the anterolateral aspects of the thighs or on the posterolateral aspects of the upper arms. Only later does the eruption spread to the extensor surfaces of both upper and lower extremities. The hands and the feet are rarely involved. The genito-anal region is almost never involved. The skin of the patient is generally darker than normal, and there is absence of sensible sweating. The normal surface markings are exaggerated, eventually leading to a finely wrinkled appearance of the skin. In fact, the eruption may eventually resemble acne, except that in the latter condition the skin is oily and sweaty. The condition, when present, should be treated for two or three months by administering from 1,000,000 to 2,000,000 USP units of vitamin A daily.

Clinical manifestations due to the deficiency of vitamin B are of several varieties, due to the many fractions of the vitamin B complex. In general, they are manifested by a lowered muscle tone, increased perspiration, irritability, nonspecific dermatitis, scaliness of the skin, dandruff, loss of hair, epidermal thickening and increased activity of the sebaceous glands. These may be complicated by glossitis, maceration of the skin in the angles of mouth, reddening of the lips, particularly along the line of closure, and scaly, green desquamations about the orifices in general. Dependable and adequate treatment in this condition consists of the use of the pure synthetic vitamin, because it is almost impossible to secure adequate intake by any other means.

The deficiency of vitamin C is usually manifested by excessive capillary bleeding, defective bone formation, petechiae around the hair follicles, impairment of wound healing and the formation of pale avascular granulation tissue. Treatment with ascorbic acid usually corrects these conditions very rapidly.

Deficiency of vitamin D is usually present in cases where one finds chronic scaly, hyperemic or ulcerating lesions of the skin. In the latter case the skin is usually atrophic, pale, loose and wrinkly. The essential function of vitamin D is to increase the absorption of calcium and phosphorus from the intestine. Wherefore, many of the cases suffering from the deficiency present oral and dental complaints. The vitamin is a very potent one and therefore should be used under careful supervision, particularly in children, in whom it can produce toxic symptoms if used in large doses over long periods of time.

Co-operation With Aids

Adequate preoperative management of a case necessitates complete co-operation of

all personnel entering into the case There fore it is important that all members of the operating team be apprized of the plan of procedure

A thorough understanding should be had with the anesthetist in cases to be operated upon under general anesthesia This includes preoperative medication type of anesthetic to be employed and its possible postoperative implications In most extensive facial operations a transnasal or an intratracheal anesthesia is indicated Allowances must be made for the physical presence of the anesthetist in the near vicinity of the operating table His position and comfort should be provided for before the operation All arrangements and set ups should tend to the one end of securing safe and adequate anesthesia without contamination of the field through the complexities of administration

The immediate assistants and the instrument nurse should have particular knowledge of the surgical procedure contemplated They must understand the reasons for the use of special instruments dressings and splints at the time of the operation This type of communion between the surgeon and his assistants is particularly important in the management of children A child is naturally shy of strangers If it is afflicted with some congenital deformity and has had unwelcome psychological experiences at the hands of other adults its management may prove to be a great problem which can be conquered only through acquaintance of the child with the personnel of the operating team The ordeal of the operation may precipitate an undesirable psychological climax in children This may not have been anticipated prior to the operation It may spell the difference between success and failure unless the child is manageable by someone on the operating team if not by the surgeon himself A child even more than an adult must be handled as a patient and never as a case This often implies exclusion of parents as visitors

Surgeon s General Condition

Finally the surgeon should take inventory of his own condition He should be in good psychological and physical mettle Obviously a surgeon never should operate if he himself is afflicted with some acute infection or distress He should abstain from operating when physically too tired emotionally disturbed or for some reason mentally not equal to the task He never should plan protracted or difficult operations for a day when he knows that during the night before other important or strenuous obligations may interfere with his integrity on the morning of surgery In other words it is imperative that the surgeon himself be in as good general physical and mental condition as is required of the patient before the operation If this is not possible the operation may prove to be an ordeal Under such circumstances it is wiser to postpone things until another day

There are times when even though in good general condition the surgeon should hesitate to add another strenuous operation to an already full program The one more case like the last draft may prove to be too much Except in an emergency his first obligations are to patients on whom he has already operated These considerations may seem like trivia or homely repetitions of obvious things yet because of their basic import the advice is risked The requirements and the exigencies of modern life make the foregoing a situation not uncommon in the busy surgeon s life

Subtle as it may be much in the execution of an operative procedure and even the results obtained depend upon the condition and the disposition of the surgeon at the time of the operation The nature of surgical work—and particularly is this true of corrective plastic procedures—is such that the surgeon is in no better position to give his best than is the artist the violinist or the professional golfer who is suffering with indigestion or indisposition To deny

this to the point of disregard simply means that the surgeon is taking another step closer to a coronary exit—the modern scourge of medical men

PREOPERATIVE PREPARATION

Preoperative preparation is the final technical step before surgery Its purpose is to reduce all surgical risk to a minimum to establish the foundation for asepsis and to delineate the surgical stage

The process may be divided into three parts the preparation of the patient the preparation of the surgical field and the preparation of the surgeon

The Patient

The general preparation of the patient involves his being placed in an easily accessible and comfortable room of such size and equipment that postoperative care may be carried out without inconvenience He should be given fluids freely especially if prolonged operations under general anesthesia are contemplated Where local anesthesia is to be used he may take fluids up to the time of the operation In exceptionally taxing operations extra carbohydrates should be given at this time Psychological reassurance of the patient is always indicated

Premedication and the type of drug to be used are matters of choice with the surgeon and occasionally they are *determined by* the idiosyncrasy of the patient The amount of the drug is influenced by age sex and disposition of the patient In any event the patient must get the proper amount of sleep water and comfort before surgery

The Surgical Field

The actual local preparations of the surgical field may be simple or complicated depending upon the complexities of the surgical procedure and the habits or the predilections of the surgeon It is never a waste of time to prepare a surgical field meticulously

The actual preparation of the skin is more important in corrective plastic procedures than in almost any other form of surgery A large number of these preps are recommended by various authors but none of these methods is entirely foolproof in itself Whatever the chemical procedure employed it is a good habit to develop the routine of preparing the field more than once before an operation In so doing one should be careful to avoid making an abrasion of the skin The shaving of the skin never should be left to a phlegmatic or careless individual who may lacerate the epithelium and make asepsis impossible

No chemical used in the preparation of a surgical field can displace mild soap and water if the latter is applied diligently It is important that the soap be in lather form not much different in consistency from that used in everyday shaving Most textbooks still advocate green soap but in my experience it is too irritating I feel that the best soaps are the white neutral castile or ivory soaps properly lathered and thoroughly applied with fine gauze or camel hair shaving brush in order to avoid injury to the epidermis This should be followed by ether alcohol and thorough drying If only one preoperative preparation of the surgical field is done exceptional thoroughness is imperative Where two or more preparations are the custom as in operations on the *hands feet genitals* or *breasts tincture of* Mercresin or a one half per cent tincture of iodine may be painted on the field only at the time of the first preparation The second or subsequent preparations should avoid using any of these except alcohol and ether The omission of chemical agents with the exception of alcohol and ether is particularly important on donor areas The advisability of repeated operative preparation is especially indicated in hairy regions since the saprophytes in the skin pores cannot be reached by a single preparation

Once the field has been thoroughly prepared it should be covered with sterile

dressings reaching beyond the contemplated surgical area These should then be securely bandaged to the part If the part is re prepared the following day as it should be the entire procedure is repeated aseptically Final re preparation should be done in the operating room

As a rule the oral or nasal mucosa is not subjected to multiple preparation Instead of soap and water half strength hydrogen peroxide is used The alcohol and the ether are omitted because of the inconvenience they cause the patient In their stead either one half per cent tincture of iodine or standard tincture of Mercresin is used On the other hand the vaginal mucosa can be prepared with soap and water but even here the ether and the alcohol are omitted except under anesthesia

An important detail in the preparation of any mucous membrane is that first it should be thoroughly dried and then cleaned only as stated above So long as the mucosa is covered with its normal secretions it is improbable that it can be prepared satisfactorily Preparation has to be delayed until the patient is on the operating table because of the impracticability of doing it at any other time

Trial Splinting

Since in so many corrective procedures splints and other mechanical aids are necessary for the maintenance of the repair some part of the time consumed in the immediate preoperative preparation of the patient should be devoted to a recheck of the splints to be employed This final rehearsal of splints and prostheses is a wise routine It avoids the annoyance such things occasion in the operating room especially when it is discovered at that late date that the prosthesis or the splint does not fit as it was intended to

The Surgeon

The surgeon should now take final inventory of himself If he regularly wears glasses at the time of operation he should be certain that these are available in serviceable condition To wear irritating glasses is a nuisance even far greater in many respects than to have to operate with a substitute instrument The hands of the surgeon should be given the proper care and grooming to see if any lesions whatsoever are present The importance of this detail becomes evident when one stops to realize that 70 per cent of rubber gloves are damaged before operations are concluded If the surgeon is in the habit of wearing certain types of shoes these should be available To stand for hours at an operating table in shoes that cause discomfort is an experience which cannot possibly contribute to success To attempt to poultice this sort of inconvenience by using the patient as a leaning board is a poor substitute for an oversight

The surgeon should be able to retire early the night before a tedious task His own health stamina and composure will have much to do with the spirit of all personnel on the morning of surgery A well laid plan attended by inadequate preparation and executed by a tired or harassed man is rarely a guarantee of a clean success

BIBLIOGRAPHY

Anderson G K The importance of protein in diet therapy J Am Dietet A 21 436 1945

Branch H E and Moldavsky L F Penicillin and bone grafting operations Evaluation of operations performed without penicillin and those performed with penicillin The Mil Surgeon 99 No 1 1946

Connolly E A Diagnosis and management for first forty eight hours Nebraska M J 31 268 1946

Darrow D C The pharmacopeia and the physician The treatment of acidosis and alkalosis J A M A 114 No 8 1940

Dixon C F and Benson R E Surgical management of large tumors of the neck Report of two unusual cases Am J Surg (N S) 69 No 3 1945

Feinberg S M Histamine and antihistaminic agents J A M A 132 No 12 1946

Jentzer A Traitement biologique des infections Paris Masson 1928

Jirasek A Uvahy O Chirurgii a Chirurgovi Uvodni prednasky klinicke z let 1927 az 1936 Praha 1937 p 23

Kazanjian V H Primary care of injuries of the face and jaws Surg Gynec & Obst 72 431 1941

Key J A Ceepryn as an antiseptic for the pre operative preparation of the skin Surgery 21 390 1947

Lund C C and Levenson S M Protein in surgery J.A M A 128 95 1945

Matthews D N The Surgery of Repair Black well Scientific Pub Oxford Blackwell 1943

Mayo C W Pre operative and post operative care of the surgical case Material Presented at Post Graduate Conference DuQuoin Illinois March 7 1940 Illinois State Medical Society

Meleney F L and Harvey H D Treatment of chronic undermining burrowing ulcers due to micro-aerophilic streptococcus Ann Surg 110 1067 1939

Parker James M The changing concepts of pre-operative and post operative care J Maine M A 38 231 1947

Passavant G Continuous water baths for burns Deutsche Klin 39 Nr 36 38 1858 (Quoted by A Rose J.A M.A Sept 29 1906 p 941)

Swan H Gonzalez R I Harris A Couslon C and Hopwood M L Use of a quaternary am monium compound for the surgical scrub Am J Surg 77 24 1949

Templeton L C Surgical preparation of the mouth for artificial restoration Am J Orthodontics 31 No 8 1945

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The Surgical Process

GENERAL CONSIDERATIONS

Surgery is a premeditated, measured and ingenious form of trauma, with the respectable purpose of ablating certain diseases and bodily defects in man or animal

Plastic surgery has for its special premise the reconstruction or alteration of defective form, function or appearance of a part with a view of improving the human organism as a physiologic unit and effective social personality

Surgery As Trauma

The surgical process from the incision to the final closure is a succession of steps each and every one of which is a form of trauma Obviously, a certain degree of trauma is absolutely unavoidable It is the superfluous trauma due to carelessness, lack of training, dramatic performance or lack of physiologic conscience which every good surgeon aims to avoid No one has yet devised any subtle way of entering into tissues or body cavities without making an incision thereby reducing the degree of tissue damage Yet no matter how minimal the injury, it bears a definite relationship to the process of healing and the final outcome of the surgical plan The degree of operative trauma inflicted upon tissues depends upon the surgeon's conscience, type of instruments used, manner of their use, quality of surgical touch, manner in which tissues are handled, type of sutures employed, mode of their insinuation, and the meticulousness and the quality of closure The relevants of postoperative care of the wound, though recognized in this connection, will be discussed in Chapter 14

Probably nowhere can a better example of tissue reaction to surgical trauma be found than in the so called tubed pedicle The tubed pedicle is a physiologic guinea pig Its physiologic experiences are almost parallel with the quality of the surgery which enters into formation of the tube assuming that the physical characteristics and the geometric requirements of the tube are within the limits necessary for survival Invaluable lessons in postoperative tissue reactions can be gained from study of the progress of a tube

It is deemed important in the elucidation of the surgical process to introduce the subject with a discussion of surgical trauma because every step henceforth described involves the postulate that surgery as trauma must be accepted as a basic factor influencing planning procedure, progress, postoperative comfort and late results

Local and General Shock

Orthopedic surgeons are well aware of the fact that in the presence of a badly fractured and comminuted femur, cruel handling of the bone fragments, undue hammering, chiseling or drilling may precipitate the patient into general shock It is equally well understood by the abdominal surgeon that much of his stormy postoperative experiences are not infrequently due to excessive handling of the abdominal contents But these are only extremes of an ever present reality, the difference being only a matter of degree Since there is no circumventing the basic truth that surgery is trauma it is imperative that no effort should be spared to avoid unnecessary pulling,

dissection tearing bleeding sponging and cruel grasping of tissues by hemostats

Though ordinary surgical processes do not necessarily lead to a general bodily insult there is always a certain amount of irremediable local cellular death and tissue shock Its degree determines the quality of a surgical result Because nerves blood vessels and lymphatics must be destroyed the resulting local dismemberment of the physiologic tissue mosaic will determine the quality of the surgical repair When the fine normal tissue balance is upset severely enough and the physiologic pattern of regeneration is interfered with it is only logical that hypertrophic scars or painful keloids should result

SURGICAL TOILETTE

With all due care exercised in the course of operation it is nevertheless necessary in respect of healing to conduct an operation with meticulous surgical toilette All blood clots should be thoroughly washed away or gently wiped out of the surgical wound Nor should devitalized tags of tissue be allowed to remain to act as biologic foreign bodies The surgical wound should be cleaned as thoroughly as an accidental wound Then it should be closed with as few sutures of as fine material and with as perfect a coating of tissue as is possible

The foregoing important as it is to all forms of surgery is imperative in plastic surgery This is particularly true in reconstructions where grafts are employed A graft whether it be skin cartilage bone or fascia in order to survive must have immediate contact with physiologically adequate tissue If between such a graft and its bed there is tissue debris even though the result of surgical instruments it is debris nonetheless and a graft has that much less chance of survival It is one of the reasons for the disintegration and absorption of grafts in the hands of one operator and their survival in those of another or in the same hands at different times

One of the best illustrations of the importance of the foregoing is the experience with free full thickness skin grafts The only bed in which such a graft will survive is in what might be termed an ideal physiologic bed In other words the tissues to which the graft is approximated must be physiologically as well as surgically clean Wherever even the smallest clot of blood is left under a free full thickness skin graft the portion overlying the clot will necrose In the case of free split thickness skin grafts which are able for a certain period of time to live upon absorbed lymph postoperative changes such as pigmentation may be the only price even though actual necrosis does not result

PREPARATION OF THE SURGICAL FIELD

The part aseptically relevant to a surgical undertaking is the surgical field In operating on any part of the upper or lower extremities the entire member constitutes the surgical field The field is dividable into a surgical area and the surgical stage The area is variable and consists of that portion of the field left exposed after draping is completed The surgical stage is that restricted portion of the surgical area subject to incision and dissection It is not necessarily represented by the extent of the defect but more specifically by that part of it selected for immediate reconstruction A surgical field is rarely draped to exhibit more than a simple surgical area But a surgical area not infrequently contains more than one stage viz Bilateral Mammaplasty Donor and Recipient sites in one area et cetera

Corrective surgery in the main is elective surgery It is therefore assumed that the preoperative preparation of the entire surgical field is of such merit as to come closest to the ideal With rare exception it is also assumed that some type of preoperative preparation has been performed at least once on the day prior to the operation

This must be followed by a re preparation of the same field on the operating table

Reports to the contrary notwithstanding all preparations should be based upon the most thorough and lavish use of neutral soap and water This is particularly important in the original cleansing of the skin Whether or not soap and water shall again be used in the operating room is a matter entirely dependent upon the nature of the case the circumstances under which one operates and the predilections of the surgeon

One of the objections on the part of some surgeons to re preparing a patient on the operating table with soap and water is that it is a relatively messy procedure This need not necessarily be so As indicated in Chapter II in the section on Preoperative Management if the soap solution is made up so that it consists essentially of suds there need be no splashing during the process of washing and when the act is terminated the foam can easily be gathered up and wiped from the surgical field without much trouble In general it may be said that where one is dealing with hairy skin or a surgical field where scarring or scabbing are extensive it is good policy to re soap the field on the operating table Whether this step is admitted or omitted some type of re preparation is indicated

In selected cases it may be sufficient to re do the field thoroughly with ether and alcohol Where no grafts are involved the field may be painted with a one quarter to a one half per cent solution of tincture of iodine or a colorless tincture of Mercresin The re preparation of the field with ether and alcohol is indicated because not all the skin saprophytes can be removed with one soap preparation no matter how diligent it may be Within from 6 to 8 hours following an original preparation the skin pores begin to disgorge themselves of residual colonies of saprophytes which will be found on the surface of the skin on the following day These and whatever oily secretions may be present are removed by the alcohol ether re preparation Assuming that the original soap and water preparation and the ether and alcohol re preparation have been thoroughly done the use of any tinctures or coloring chemicals upon the skin is purely a matter of choice Their essential value undoubtedly lies in the fact that they lend distinctive color to the surgical area and make the draping thereof somewhat easier In plastic procedures they can be a decided nuisance by obliterating detailed skin markings

According to John Staige Davis tincture of iodine picric acid solutions mercurochrome and others if used several times prior to the operation are usually sufficient for proper aseptic preparation of the field The statistics submitted in support of this contention seem reasonable enough in consideration of the perspective of the experimental effort Notwithstanding if these chemicals are not used in diluted form they can be irritating to the skin Secondly where skin details are used as guideposts to incisions or the outlining of flaps and grafts any obliteration of these markings by dyes or stains may interfere with accurate delineation Personally I do not feel that any chemical can take the place of soap and water lavishly used

Where grafts are contemplated there is always the possibility of wiping the chemical paints into the surgical wound and setting up a foreign body reaction which may affect the fate of the graft Probably a wise combination of the soap and water preparation with the chemical paints where permissible is the most reliable form of surgical preparation

No matter what method of preparation is employed other things enter into the establishment of surgical asepsis One of these is the manner of preparation of the surgical area itself A surgical area always should be prepared from the stage out toward the periphery All preparations should begin with the scar or the defect (stage) to

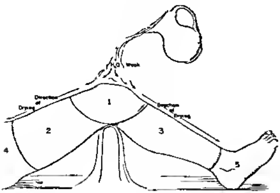


FIG 41 Centrifugal preparation of surgical area No 1 is the surgical area All preparation begins at that point and progresses outward according to numbers never returning to the previously soaped area with the same gauze cotton or brush whatever the medium used for scrubbing Drying of the extremity is carried out in the same numbered sequence No 1 may be temporarily covered by sterile towel while draping the extremity

be removed If no defect is present the site for the incision (stage) should be elected as the point of initiating the preparation (Fig 41) The materials used in the preparation of the immediate site for operation particularly in the case of an ulcer or a scar should be discarded before preparing the part or the field Once the defect has been thoroughly prepared it should be covered with sterile gauze the remainder of the surgical field is then ready for attention

What has been said about the preparation of the surgical field also applies to its drying All drying should be done centrifugally In other words a sponge used to wipe the defect should be placed in the center of it drawn toward the periphery and then discarded Such homely details are at the bottom of adequate and reliable asepsis They should be no more neglected or disavowed than the proper dressing of a surgical closure (Fig 41)

Once the surgical field is prepared it may be draped Draping delineates the surgical area from the surgical field Draping is too frequently done in a haphazard manner Nevertheless it is one of the most important factors in modern surgical asepsis The proper and adequate draping of a surgical area is one of the earmarks of good technic There are many ways of draping Nevertheless all of them can be reduced to a common denominator

Draping should follow more or less the pattern of preparation In other words it should be done from the center out toward the periphery First of all the operative site should be covered by sterile gauze or a folded towel (Fig 42) Then the area depending upon its geometric configuration should be fenced in by carefully placed towels so spaced that the area is neither too

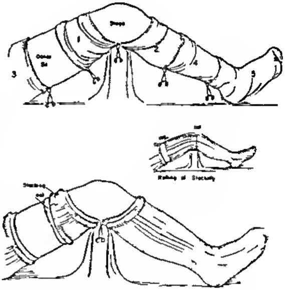


FIG 42 Centrifugal draping (*Top*) Order of application of towels Where no donor site is needed towels No 1 and No 3 meet (*Bottom*) Use and application of stockinet coverage over towels its severance over surgical stage donor site and exposure of the two In the case of the knee joint the stage and area become practically one due to retraction of stockinet Additional towel coverage may confine the operator exclusively to the stage (point of incision) and yet give him ample opportunity to expand without exposing unnecessary areas 1 or 2

Fig 43A Examples of draping (*Top*) Method of draping lower extremity with lesion of heel where donor site for graft is the thigh Note secure draping and exclusion of foot and leg to heel secure coverage of groin and total coverage of other leg Also observe temporary coverage of heel (recipient site) while graft is being mobilized from thigh (donor site) Finally note interim replacement of free graft on donor area until actually needed at recipient site (heel) this protects graft from desiccation or accidental loss

(*Bottom*) Method of draping the head for exposure of left mandible Note exclusion of all features except area of mandible indicated by long curved line The lobe of the left ear is barely visible under sterile towel tightly wrapped around head Partial exposure of the ear lobe may be an aid in orientation during surgery Vertical lines below index finger of gloved hand—site of mandible pathology

restricted for comfortable performance nor so charitable that in the course of the operation any unnecessary site may come into view The towels delineating the extent of the surgical area should be securely fastened so that there is little chance of displacement during the operation In the original placement allowance for change of the area must be anticipated without exposing the initial site to contamination from adjacent parts

The entire patient is then ready for draping This is probably done more carelessly than anything else in the operating room Too frequently the sheets which are to cover the patient as a whole are thrown over him in a spirit of keeping him from catching cold rather than to serve their more important purpose namely to integrate the patient the operating table and surgical team into an aseptic whole Every part of the patient should be as thoroughly and carefully covered by sterile material as is the surgeon himself

Once the surgical area has been delineated and the patient is completely draped

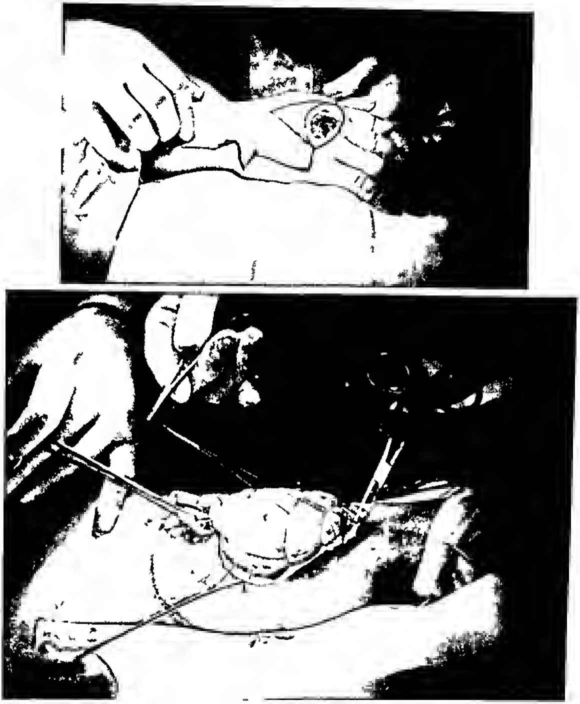


Fig 43B Examples of draping (*Continued*) (*Top*) Position and draping of right hand for extensive surgery of dorsum Note coverage of fingers by rubber cots and proximity of drapes to outlined incisions For purpose of type of incision, see Chapter 28 (*Bottom*) Draping of leg for extensive excision of compound gunshot wound Note proximity of draping (inferior and superior) to wound Roll of gauze initially sutured to defect to preclude contamination of colateral tissues from wound Excision is carried around bundle coverage An additional feature of the bundle coverage is that the lesion can be manipulated easily in toto without much difficulty

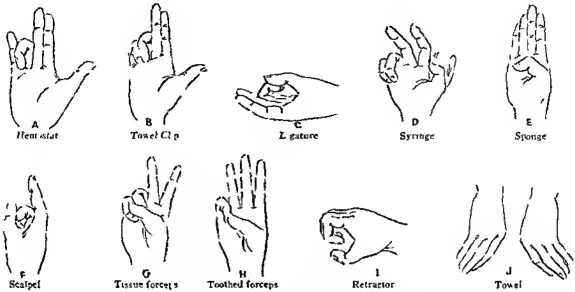


FIG 44 Hand language (after Poole and Bancroft)

the folded towel originally placed to cover the site of incision or excision should be discarded The removal of this towel can be used as a sign that the operation is to begin

Experience has shown that certain adequate methods of draping specific parts, with variations of detail, can be routinely applied Examples of these will be found illustrated in the accompanying Figure 43

OPERATING ROOM LANGUAGE

Hand Language

From the moment the surgical stage is exposed and well illumined, a patient under local analgesia suspects the operative ordeal Under general anesthesia the patient is no problem But since most corrective procedures are done under some form of local analgesia, this moment is a severe emotional test for many patients The degree to which patients react at this time varies with their psychological makeup The patient's reactions and behavior during the operation may greatly influence not only the comfort of the surgeon but his efficiency as well

The whole business is a kind of test of the patient's mental endurance (particularly when his eyes are covered) in reconciling his predicament with the surgeon's repeated requests for the knife scissor chisel and so on through the entire array of sharp instruments These to the timid patient are suggestive of pain discomfort and occasionally danger Most patients it is true show no outward sign of anxiety under these conditions but if questioned postoperatively, many will admit that one of the most discomforting phases of being operated upon under local analgesia is to have to listen to the surgeon calling for sharp instruments

Various forms of sign or hand language have therefore been devised to replace the ordinary verbal means of communication between surgeon and operating room personnel Poole and Bancroft have suggested a rather ingenious though restricted, form of communication through the use of the right hand (Fig 44) Most surgeons presumably practice some form of hand language at one time or another

Personally I have come to the conclusion that, although it is a good psychological substitute for verbal communication, all

forms of hand language are inadequate im practical and difficult if not contrary to aseptic technic Frequently occasions arise where the surgeon while operating wishes to suggest to his assistant that he change instruments It is not practical for the surgeon while palpating or dissecting some detail of the operative wound to take time out to signal his assistant or the instrument nurse for things to be handed to some one at the operating table On the other hand the instrument nurse may stand in a position where some one of the assistants immediately connected with the operation has to make way for her to see the hand signs This at least momentarily disqualifies the assistant What is worse the operation often has to wait for the communication Should it be impossible for the assistant to make way for the nurse to see the surgeon may have to project his gloved hand above the shoulder line below his waist line or behind the back of his assistant Any one of these is contrary to rigid asepsis It is also an impractical method because not all surgeons are capable of performing some of the rather complicated finger maneuvers necessary Finally the possible variations of the sign language are too limited to include even a part of the surgical armamentarium in ordinary use in general surgery let alone the specialties

Since it is at least theoretically possible that ordinary operating room language is not an aseptic form of communication and that not all surgeons are gifted with enunciation clear enough to be easily understood the requisitioning of special instruments may involve almost a debate between the surgeon and the instrument nurse unless the latter is a permanent fixture with the surgeon Therefore it would be advantageous to have some form of abbreviated communication which could be easily understood quickly mastered and still adequate for general use To this end the author has found a number language more adequate than hand language

Number Language

It seems to me that the method of communication which answers the problem best is a system based upon numbers Certain instruments such as the knife scissors hemostat retractor probe and others are in general use by all surgeons They are for the most part sharp or potentially injurious instruments Their number is relatively small

Since the knife is used by all surgeons it is assigned the number 1 Irrespective of the pet knife which a surgeon prefers it always carries the number 1 This numeral then has not only general applicability but also specific meaning Since most surgeons employ standard knives such as the Bard Parker removable blade it is not difficult to identify the different knives by simply suffixing the number 1 by the number of the Bard Parker blade If for instance one desires a scalpel consisting of the pointed blade the call is for 1 11 If one need the smallest of the blades the call is for 1 15 The important thing so far as the patient is concerned is that the word knife need never be mentioned

Accordingly all needles are assigned the call number 0 scissors the call number 2 hemostats the call number 3 etc (Chart 3) If one now wishes to employ a needle gauge #23 it is only necessary to call for 0-23 The same again applies to identifying various types of scissors If one wishes to use a scissor not ordinarily numbered one calls for "2 Mayo curved on flat" The index number of the chisel being number 4 the various sizes are simply identified by their width in millimeters as for example 4 12 by the numbers stamped upon them by the manufacturer or by the manufacturer's name

There are certain other expressions used at the operating table such as the words *cut clamp* or *pull* which to a conscious patient under local analgesia are anathema to equanimity These are identified by the

letters X Y Z respectively In other words when the suture is tied one simply refers to the cutting by saying X to the assistant The point at which the surgeon wishes the assistant to cut the suture is simply indicated in millimeter distance from the knot If it is desired to have the suture cut one centimeter from the knot the call number is X 10 a millimeter would be X 1 etc

For purposes of general surgical use it is not felt necessary to extend the language beyond number 10 If for any reason the specialist wishes to identify certain unusual instruments by a number this can with ease be explained to the surgical nurse who being conversant with the basic system can very readily memorize one or two additional numbers For example if the surgeon uses a cautery frequently the call number 21 seems apropos

The basic advantage in any system based on the number is that the numeral is much more quickly pronounced takes less time is more easily heard and understood than are ordinary words Further than that there is less difference in the enunciation of numbers by different operators than in the pronunciation of ordinary words Finally it is much easier for all members of an operating room force to remember the number language than any other This applies to practically all the languages of the world It is sufficient for ordinary purposes that those only secondarily connected with the operation need have only a general knowledge of the principal numerical designations of functional instruments used in all sur

THE NUMBER LANGUAGE

Instrument	Identification	Extension	Identification
Needle	0 —	Needle Holder	0—Holder
Knife	1 —	Paracentesis	1—Paracentesis
Scissor	2 —	Dissecting	2—Secting
		Cutting	2—X (see below)
Hemostat	3 —	Straight	3—Straight
		Curved	3—Curved
		Mosquito	3—Mosquito
Chisel	4 —	Prefix size by 4 or	4—12
		Prefix name by 4	4—Nasal
Probe	5 —	Prefix shape by 5 or	5—Dental
		Prefix kind by 5	5—Long
Saw	6 —	Prefix name by 6	6—Josef
Retractor or Hook	7 —	Prefix name by 7	7—Illuminated
		Identify as single or	7—Triple
		double by number of prongs	7—Rake
Rasp	8 —	Suffix number by shape	8—Convex
		Prefix name by number	8—Nasal
Drill or Trephine	9 —	Prefix size by 9 or	9—4 (mm)
		Prefix type by 9	
Hammer or Mallet	10 —	Prefix type by 10	10—Metal
			10—Large
Cut	X —	Cut short	X—Short
		Cut long	X—Long
		Cut 2 mm	X—2
Clamp	Y —	Clamp edge	Y—Edge
		Clamp tight	Y—Tight
Pull	Z —	Pull to left	Z—Left

Chart 3

gery and not any incidental numbers peculiar to a given specialist

Chart 3 illustrates the basic principles of the number language intended only to cover such instruments in general use by all surgeons as might suggest pain or discomfort to the unanesthetized patient These can be combined or elaborated upon to suit the peculiar needs of the surgeon without jeopardizing the value of the basic system

ANESTHESIA

General Considerations

Modern anesthesia is a far cry from the primitive kind induced via the soporific sponge saturated with the juices of narcotic herbs one of which contained scopolamine After being moistened these sponges were tied over the mouth of the patient to be operated upon so he could lick the juices from the sponge and by swallowing them eventually attain a state of analgesia if not true anesthesia

Anesthesia is one of the cornerstones of modern surgery It stands on a par with asepsis the control of hemorrhage prevention of shock and exact postoperative treatment It is not only surgically indispensable but of definite physiological consequence Its importance in surgery therefore merits the planning and the consideration accorded all other phases of the art The choice of the proper anesthetic and its method of administration must always be an integral part of exact preoperative planning Not uncommonly the attitude is one of nonchalance toward this problem It is unfortunate both for the patient and the surgeon Anesthesia never should be taken for granted

All forms of anesthesia—general regional block and local desensitization—are used in plastic surgery Due to the length of time operatively consumed in most cases local spinal regional or block analgesia is preferred by most plastic surgeons

This applies to children as well as adults With the proper psychological approach to a child it is usually not too difficult to gain his confidence It is almost as common to see anxiety in an adult at the time of introduction as it is to see fear in a young child It is therefore good practice to establish proper psychological management with all patients irrespective of age

Premedication

No matter what type of anesthesia is decided upon basal hypnosis should be given consideration It is important to the patient s bodily economy as well as to the surgeon s peace that the patient get a good night s rest and be in a healthy frame of mind on the morning of surgery The most commonly employed drugs for this purpose are avertin and the derivatives of barbituric acids Whether the patient is an adult or a child it is well not to get into a phlegmatic habit of administering routine dosages of these drugs The dosage should be determined for each and every individual case particularly so in children

A certain degree of anxiety on the part of the patient prior to an operation is a normal reaction The degree varies from one individual to another and even in the same person from time to time There is no way to evaluate the severity of the anxiety except through questioning of the patient The patient s reply must be the sole guide The integration of the patient s attitude and the painful experience he anticipates during the operation is the function of the cerebral cortical level The imposition of this factor can be minimized as heretofore indicated by the intelligent use of basal hypnosis To allow rampant and uncurbed control to the cerebral cortical levels is to risk a surgical experience as an ordeal Experience with protracted operations dictates the advisability of using some form of basal hypnosis in every instance

The use of morphine and its derivatives in this connection is discouraged because

though the most potent of all analgesics it has a number of undesirable pharmacologic side effects and therefore should be used only in exceptional and difficult cases Some of the allied drugs like Pantopon or Demerol which are less toxic and inhibitory are preferable Pantopon gr 1/3 to 2/3 with Scopolamine gr 1/150 per Hypo for adults is a most reliable form of premedication to local analgesia In infants and children Pantopon gr 1/16 to 1/8 with Atropine Sulfate gr 1/400 to 1/300 is preferable

Induction

Whether a general anesthetic or local analgesia be used the method of its induction is much better determined preoperatively Particularly is this true where surgery is done on the head and the neck Surgical rhythm and peace of mind depend greatly upon a thorough understanding between the surgeon and the anesthetist

In head and neck surgery the transnasal or the intratracheal route of administration of a volatile anesthetic usually answers the need The well trained and experienced anesthetist finds it no more difficult to give general anesthesia by this route than by any other In fact most anesthetists prefer to administer via the nose or the trachea because once anesthesia is established all conditions conducive to asepsis and ease of performance are much better controlled in this way The anesthetist has the patient under better physiologic control by this means and the surgeon usually enjoys better physical freedom during the course of the operation

Local or block analgesia is best induced by blitz insertion of the needle planned distribution of dermic wheals raised by the finest available hypodermic needles or focal digital pressure These make induction a painless experience Local analgesia is accomplished by forcibly casting the needle at a predetermined skin target with sufficient impact so it traverses the epicritic level with lightning speed (1/25 sec) The other methods will be described separately under Local Analgesia

Types of Anesthesia and Analgesia

There are three main forms of tissue desensitization to pain local analgesia regional analgesia and general anesthesia All three are employed routinely in plastic surgery They may be established in many ways but only such will be discussed as are of particular interest to the plastic surgeon

General Anesthesia With growing physiologic consciousness in modern surgery general anesthesia is receiving more critical attention than it has for a decade It is obvious that an acute and radical change in the physiology of the individual is precipitated by general anesthesia Many of the functions of the organism are noticeably affected There is an immediate general disturbance of the process of cellular oxidation almost complete exclusion of the temperature regulating center the circulation is materially slowed the blood pressure falls there is an upset in the rhythm of respiration as well as in its depth and in prolonged anesthesia dehydration is a major factor as evidenced by the amount of fluids that must be given where the anesthesia has continued for three or more hours If this is not done the processes of the body as a whole are thrown out of equilibrium

Notwithstanding the fact that the fatalities and the accidents in general anesthesia in the past two decades have been materially reduced a certain percentage of anesthesia casualties still occurs The percentage of those physiologically hurt is much higher than one is ordinarily led to believe If one only takes the trouble to bear this in mind and follow patients postoperatively it is amazing how frequently one is faced with a relative physiologic casualty which is the result of a general anesthetic

Most postanesthetic physiologic lameness can usually be avoided by proper preoperative preparation of the patient and expert

operative return to consciousness and the apparent establishment of the clinical norm is also much more rapid than it is with ether I never have seen a serious complication following the use of ethyl chloride general anesthesia at the Czech Institute during a period of months

PENTOTHAL SODIUM The most recent addition to general anesthesia is intravenous Pentothal Sodium Pentothal Sodium administered intravenously with oxygen is generally recommended for short operations Yet most of our expert anesthetists in the Army Medical Corps during World War II were able to administer Pentothal Sodium and oxygen for operations lasting many hours On one occasion I had the privilege of working with an anesthetist in the Service who administered Pentothal Sodium and oxygen continuously during a plastic procedure lasting over a period of 6½ hours with no observable ill after effects to the patient On another occasion I had the opportunity of operating on a patient who received continuous Pentothal Sodium oxygen anesthesia for over 10 hours without any ill after effects In both cases we were dealing with unusually extensive war injuries in young men who were otherwise in good general condition

Were it not for the depressing effects upon respiration Pentothal Sodium intravenously would be an ideal anesthetic Consequently the administration of oxygen with the Pentothal Sodium is a necessary adjunct

It is the opinion of Bullard Brockett that "while Pentothal Sodium alone or with oxygen is suitable for short operations, Pentothal Sodium in combination with nitrous oxide oxygen is, we believe a much more desirable anesthetic for use in oral surgical procedures requiring more than the minimum of time"* They add that there is no explosion hazard and that nausea is rare

* Bullard O K and Brockett S I Combined *pentothal sodium nitrous oxide oxygen anesthesia in* oral surgery, J Oral Surg 3 138 151 1945

Another recommendable combination is Pentothal Sodium alternating with local procaine infiltration I have employed this procedure in operations lasting up to 9 hours The surgery begins under local analgesia and with the expiration of every hour on the hour ten minutes of general anesthesia via Pentothal Sodium is induced If it is possible to time this with deep tissue excision or dissection it saves much time The most important factor in the form of combined anesthesia is that it so relaxes and refreshes the patient he is able to endure the ordeal of long operations without the usual discomforts

ALCOHOL The ease of administration and technical appeal of an intravenous general anesthetic has tempted the Russians to the use of alcohol for this purpose On the premise that both chloroform and ether are too toxic to the heart muscle kidney liver and lungs and since local analgesia is inadequate for extensive intra abdominal and thoracic operations as well as for bone surgery in the presence of extensive scarring they have resorted to intravenous alcohol

L V Verkhovskaya in the American Review of Soviet Surgery for February 1945 reports on 30 operations performed under intravenous alcohol anesthesia The procedure used is as follows 2 cc of a 1 per cent solution of morphine is administered one half hour before the operation The patient is recommended to be in a fasting state The intravenous administration of 1 part of 95 per cent alcohol with 2 parts of 5 per cent glucose is then started on the operating table The average dose for complete narcosis is from 2 0 to 2 5 cc per kilogram of body weight In other words a patient weighing 60 kilograms, would require 120 cc of alcohol and 240 cc of 5 per cent glucose solution The mixture should be prepared on the day of the operation The glucose solution is sterilized individually, and then the required amount of alcohol is added just before the injection This mixture is given over a period of from 15 to

20 minutes and as soon as the patient falls asleep the injection is stopped When the patient shows any signs of awakening the drip is resumed It usually takes about 40 to 60 cc of alcohol before sleep sets in The anesthesia resulting usually lasts from 2 to 5 hours

Certain dangers and complications are admitted by the author Vomiting is not infrequent Temporary retention of urine is not unusual headaches are quite frequent red blood cells are often found in the urine There is also the danger of local thrombophlebitis immediately after the injection of the solution wherefore it is advised to follow the intravenous infusion with from 20 to 40 cc of physiologic salt solution as soon as the patient falls asleep

Anoxemia resulting from the administration of intravenous alcohol is much more severe than that which follows the intravenous administration of ether or of sodium pentothal In fact the alcohol produces a kind of acute toxic condition which is manifested clinically by unconsciousness and certain clinical laboratory findings mentioned above I have employed this anesthetic only on three occasions and do not see any advantage in the adventure

All general anesthetics thus far used be they inhalation or intravenous in type have one physiologic misgiving in common and that is anoxemia This is only partially compensated for by the direct administration of oxygen The exclusion or the lack of oxygen is not only an undesirable element in general anesthesia but the most dangerous link in the entire phenomena of narcosis To quote Haldane Anoxemia not only stops the machine it wrecks the machinery

Spinal and Block Analgesia Both spinal and block analgesia are very useful forms of regional tissue desensitization to pain Spinal analgesia is particularly useful in plastic surgery of the lower extremities the genitals and the perineal regions It is easily administered comparatively safe and adequate for almost any type of plastic surgery of the lower extremities lasting up to 3 hours It is a rather quickly acting form of analgesia with complete relaxation and when properly administered there is negligible danger to the cord or to the life of the patient

The greatest danger in the use of spinal analgesia lies in the paralysis of the respiratory center when the anesthetic diffuses too rapidly and too high within the spinal canal To avoid this all important complication so-called continuous spinal anesthesia has been recommended This consists fundamentally in a partial injection of the total amount of the solution estimated for a given operation and is started usually with from 20 to 30 per cent of the original amount and is then followed by additional smaller injections at periods varying from one-half to 1 hour If the patient lies on his back while being operated upon as is usually the case the proper cushioning of the patient must be arranged for permitting of retention of the intraspinal needle during the entire course of the operation The repeated injections of small amounts of the drug reduce the hazard of complications and particularly respiratory paralysis to a minimum and in no wise interfere with performance of the surgery The method has the additional advantage of being subject to termination even before the operation is completed or at any moment during the surgery if the indications exist This precludes the injection of too little or too much of the anesthetic which is not impossible with the single dose For this purpose the Lemmon anesthesia mattress is suitable

From an experience with over 1 000 operations performed under spinal analgesia 112 of which were done under so-called continuous spinal analgesia there has not been one fatality In only two instances where the anesthesia reached a very high spinal level (each case consisted of a single intraspinal injection of the total amount

of the drug 125 milligrams) did there seem to be any danger With the presence of an expert anesthetist and the proper administration of oxygen both cases were immediately brought under control

The later postoperative consequences of spinal anesthesia are few The reported intraspinal complications would seem to be due to improper administration or the inadequate postoperative management of these cases rather than to the anesthesia itself For instance the severe headaches which occasionally follow this type of analgesia can be avoided if the patient is impressed with the necessity of lying quietly for 3 or 4 hours or more after the termination of the operation

Block analgesia whether single trunk or of the plexus type is another useful form of regional analgesia not employed frequently enough in surgery It is particularly useful in operations upon the upper extremities where local or spinal analgesia is impractical or at times contraindicated There always should be a waiting period of at least one half hour or more before the operation is started In single blocks the anesthetic is injected immediately about or into the nerve sheath whereas in the plexus type the drug is injected in close proximity so as to find itself as near the vicinity of the origin of the plexus as is possible By diffusion usually in about 30 to 40 minutes the block becomes established For technics of administration the student is referred to works exclusively devoted to the subject of anesthesia

Refrigeration Anesthesia The most recent attempt at the production of regional anesthesia has been so called refrigeration anesthesia The principle underlying this is simply the well known physiologic fact that the lower the temperature of a tissue the lower its threshold of conductivity The modus operandi consists essentially of chilling a limb or a part thereof the relative cutting off of blood supply by means of a tourniquet and the gradual postoperative thawing of the part to avoid precipitous pathologic complications

It is the analgesia of cell protoplasm in contrast with other forms of anesthesia which act upon or through the nervous system—peripheral or central It is recommended as being particularly useful in diabetics and patients suffering with extensive arteriosclerosis Many physiologic advantages are claimed for this form of anesthesia such as the absence of pain after operation inhibition of infection control of edema reduction of embolism and conservation of poorly nourished tissues as well as the avoidance of shock To what degree these things hold only time will tell since this form of analgesic has hardly been given a fair trial It seems useful in selected amputations more so than in any other form of surgery

The analgesia is induced by placing ice bags around a part at and below the level chosen for the tourniquet one half hour prior to the application of the tourniquet The part is then elevated to drain it of its blood before the tourniquet is closed Approximately from 2 to 3 hours of refrigeration is required depending upon the amount and the quality of the tissues to be amputated The skin temperature is maintained at 40° F until the moment when the patient is placed on the operating table

Various and ingenious electrical contrivances have been devised to dispense with the use of raw ice and their use has made the induction more controllable and less messy Such apparatus is also useful postoperatively in the control of thawing A cradle which can be controlled thermostatically at low temperatures guarantees better asepsis and ease of handling postoperatively than raw ice

This type of regional anesthesia will find little use in plastic surgery since the application of the tourniquet which is so important for exclusion of the circulation is difficult outside of its use in connection with extremity surgery Without the tourni

quet refrigeration anesthesia is inadequate except for minor incisions

Local Analgesia The most widely used and satisfactory form of tissue desensitization in plastic surgery is local analgesia The reasons for this are that the operative time consumed is either so short or so extended the field of operation so restricted or so placed the surgery so relatively atraumatic that general anesthesia is either superfluous unnecessary contraindicated or too involved Where reconstructions involve bone joints or internal organs general anesthesia may be inescapable or indispensable But for the majority of operations in plastic surgery local analgesia is the one of choice

A solution of from one half to 2 per cent procaine hydrochloride is the most commonly employed To the solution of procaine is usually added adrenalin chloride 1 1 000 from 5 to 15 drops per ounce of procaine solution When the smaller amount of adrenalin is used it can be repeated in 3 successive ounces of the procaine solution just so the total amount of adrenalin does not exceed 1 cc When the larger amount of adrenalin is used it is incorporated at once in the first ounce of the procaine solution and is never repeated during the course of the operation The latter method has the advantage in that it more definitely freezes the procaine into the tissues at the beginning of the operation One of the dangers of the massive dose method of adrenalin is the fact that not infrequently the surgeon finds patients very sensitive to the drug The reaction thereto may be quite severe or even alarming Wherefore it has been the custom with most surgeons to use the smaller amounts of adrenalin and repeat them with subsequent injections of the procaine On the other hand if one plans to use more than 3 ounces of the procaine solution during the course of an operation say 5 ounces in all it is not wise to use only 3 drops of adrenalin in each ounce but better to use 5 or 6 drops in each of the first 3 ounces It will be found from experience that if less than 5 drops of adrenalin is used to an ounce not enough of the drug is present to freeze the procaine The ideal amount of adrenalin to one ounce of procaine seems to be between 6 and 8 drops

Though drugs such as procaine used for local infiltration of tissues have very little effect upon healing of tissues as a general rule the rule is not an exclusive one Certain drugs used for this purpose have not only local but general implications occasionally of severe degree

Induction The technic of the administration of local analgesia too frequently is a kind of haphazard stabbing procedure without plan This is as unfortunate as the clumsy induction of a general anesthetic The technic of local infiltration should be as simple and as logical as possible If it is visualized preoperatively as it should be much time is saved in the operating room and much annoyance is spared the patient It is not necessary to edematize the entire operative stage by flooding the subcutaneous tissues with the solution It does nothing for the quality of the analgesia and leads to distortion of tissues and tissue relationships

Adequate anatomic blocking of a surgical stage can be accomplished only by sensible geometric planning of the procedure This cannot be done accurately adequately or neatly by the use of only one needle It is necessary to plan and to choose the number and the type of needles for a geometric type of infiltration so as to fence in completely the entire surgical stage (Fig 45)

When the infiltration is begun it should be done with the sharpest and smallest needle available This is not only intelligent but desirable because this part of the operation dealing with infiltration is so often the thing most dreaded by the patient Secondly the larger the needle the greater the trauma to the skin and the sub

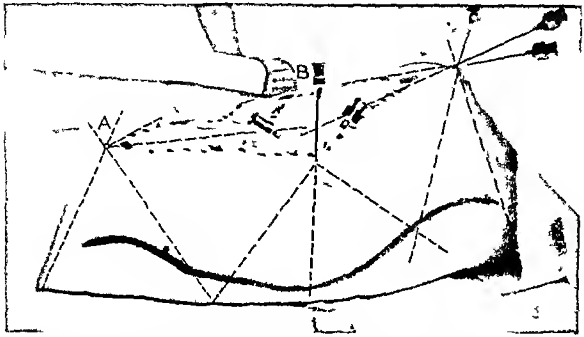
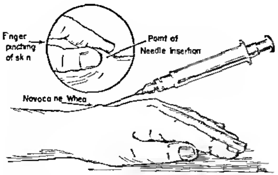


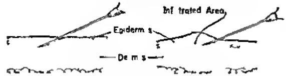
Fig 45 Fencing in of surgical stage with needles for local infiltration Dotted lines indicate direction and extent of needle projections for complete crossfire infiltration All the needles (in this case 12) are inserted through previously raised epidermal wheals before any infiltration is begun Syringe with novocaine is then attached to one needle after another and while the latter is slowly withdrawn the analgesic is injected The needles in this case are shown surmounting extensive defect over left tibia Concave black line on side of leg is the site and extent of incision for double pedicled bridge flap

cutaneous tissue Whereas in other forms of surgery even an intravenous needle may be a relatively insignificant instrument as related to tissue trauma in plastic surgery the wound resulting from a large caliber needle is frequently too important to disregard in consideration of the minutiae demands of this type of surgery The immediate cutaneous trauma sustained as a result of the use of a large needle is not the only important consideration The subcutaneous trauma particularly to blood vessels fatty tissue and nerves is fully as important The insinuation of a large needle frequently produces immediate subcutaneous oozing of blood so extensive by the time the incision is made and the surgeon reaches into the deeper tissues that he finds himself in the midst of a hematoma Such a hematoma materally interferes with repair and post operative healing Finally the use of unnecessarily large needles leads to such rapid infusion of the procaine solution as to produce at times acute local disruption of cell patterns which give way to postoperative lymph infusion of the wound swelling and fibrosis necessitating prolonged periods of tissue reorganization thus delaying functional recovery

Having chosen the proper needle with which to make the initial puncture one should pick up the skin at the site of injection between the index finger and the thumb of the left hand (if one is right handed) and pinch off a unit of tissue until blanching occurs This form of manual compression not only splints the tissues and makes the raising of a wheal easier but produces a certain degree of focal analgesia which permits of kinder insertion of the needle through the epidermis so that the patient is hardly aware of the act With a little



RAISING OF NOVOCAINE WHEAL



SECTIONS ILLUSTRATING WHEAL

Fig 46 Raising of epidermal wheal Elevation and pinching of skin by thumb and forefinger result in a degree of analgesia which makes initial insertion of needle more tolerable to an anxious patient

practice this can be done so quickly and so well that the patient is entirely unconscious of the entire procedure (Fig 46)

The initial puncture should extend only to the derma A wheal is then raised before the needle is projected any deeper At this point if the field of operation is extensive the original needle is replaced by a larger and longer needle but most of all a needle as long as possible apropos the size of the operative field This is then insinuated through the skin and into the subcutaneous tissue via the original wheal without attaching the hypodermic syringe The original cutaneous wheal can then be used as a hub for the insertion of additional needles radiating in various directions so as to cover as much of the operative stage as possible with as few needles as possible (Fig 47)

Another wheal can then be raised at the opposite pole or corner of the surgical stage and the same process repeated When the number and the placement of the second ary needles are such as obviously to cover or fence in the entire surgical stage, the infusion is begun The barrel containing the procaine is attached to one needle after the other and as the procaine is being slowly injected the needle is gradually withdrawn When the last needle has been withdrawn one can be certain that an adequate infiltration of the entire surgical stage has been accomplished (Fig 48)

There are certain technical advantages in this method not enjoyed by the customary procedure of infiltration at the same time as the needle is being pushed through the skin and the subcutaneous tissues

When the needle alone is being directed through a tissue without injecting the procaine it is the only certain way in which accurate depth and direction of that needle can be controlled If done carefully there is no discomfort or pain to the patient while the needle is being projected subcutaneously, since practically all the pain the patient feels and fears customarily is that resulting from the original puncture of the epidermis itself Since in our case this is always done through the original wheal or any subsequent wheal properly placed the pain as well as the trauma attending local infiltration is reduced to a minimum The injection of the solution as the needle is being withdrawn allows the surgeon a better chance of visualizing the exact amount and placement of that solution by not having to watch the progress of the needles Instead one is able to concentrate upon the graduations of the hypodermic barrel and so control or even vary the amount of the procaine solution injected at any one point

The foregoing technic of tissue infiltration is particularly recommended in doing a nerve block By raising a cutaneous wheal and then smartly plunging the needle in the direction of the nerve trunk it is obviously much easier to direct the point of the needle in depth as well as course than if the deep tissues are first displaced by infiltration which has preceded the point of the

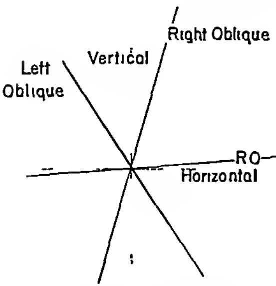


FIG 50 Designation of right and left oblique incisions is based upon vertical polarity of body and its appendages The point where the broken vertical and horizontal lines meet denotes the center of surgical stage or defect Perineal anal and plantar incisions are based on dorsal position of patient during surgery

the muscle it is an incision which runs parallel with the directions of its fibers an example of the combination of the two is McBurney s incision A conditional incision is one dictated by circumstance or necessity The outstanding examples of the latter are the so called rectus crucial and guillotine incisions

Not all of these terms need necessarily be applied in the description of any one incision because any of them under given conditions may imply one or more other identities For instance a structural incision (S I) of a muscle obviously implies the direction of the incision A horizontal incision of the anterior neck implies the fact that it is a structural functional incision (S F I) But where conditions arise necessitating exact identification of an incision the proper combination of the above terms will set it aside from the other related incisions without the necessity of illustration

These terms on the other hand can as well be applied to accidental lacerations and injuries For application of such nomenclature in the case of accidental injuries see Figure 49 The practicability of such strict identification of the position type and kind of laceration becomes more obvious if one attempts to visualize accurately an injury described by another

In most branches of surgery the simple conditional straight (S C S) incision is the one most commonly employed In plastic surgery such incisions are frequently inadequate or even contraindicated Whereas in general surgery direct simple approach is the dictum which decides the position the direction and the extent of the incision such is not always the case in plastic surgery Incisions in this specialty are constantly influenced by functional physiologic and esthetic factors as well as the pathology involved

The insidious influence of fibrous tissue contraction on the contour of a part is so important in plastic surgery that incisions are seldom made beyond a certain length in any one direction Straight line incision in plastic surgery always should be as short as possible depending upon the dimensions of the part If a short straight incision should prove to be inadequate for proper approach this must be made easier not by direct extension of the original incision but by continuing the original incision in a different direction Hence the popularity of the so-called zigzag incisions in plastic surgery

All straight line incisions and especially those crossing flexion creases shrink in the line of their polarity This shrinkage may amount to as much as 70 per cent of the original length of the incision The consequence is a fiddle string contracture That type of incision and its consequences will not only affect the symmetry of the repair but also will interfere with function (Fig 52)

The principle of the avoidance of long incisions or lines of closure applies to the repair of accidental lacerations as much as to surgical incisions Therefore in the closure of lacerations the plastic surgeon often

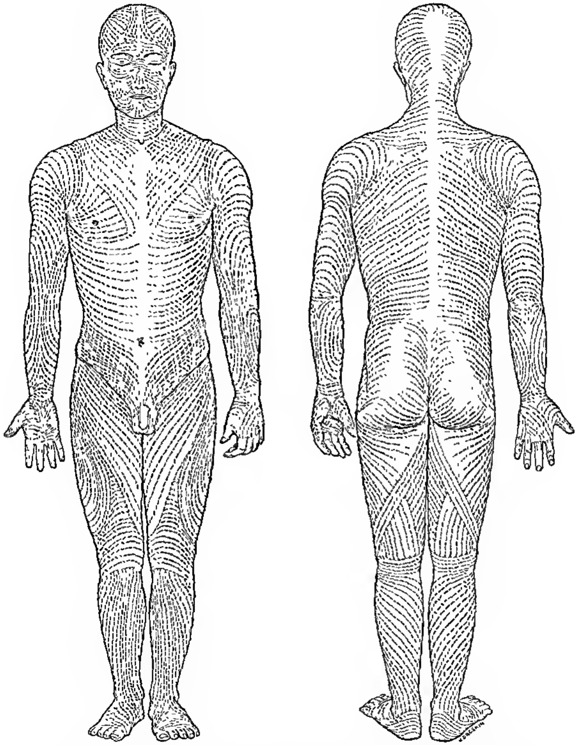


FIG. 51. Langer's lines of tension. These vary in detail from one individual to another. They can be relied upon only in a general way. In practice, each topographical skin surface must be surveyed at the time of operation for detailed variations of lines of tension.

deliberately incises into the lips so as to break up the eventual pull or unilateral tension of the wound (Fig 53) By making several judiciously placed radiating incisions into the side of a wound, several small flaps are created which, when properly shifted across the polarity of the defect, guarantee avoidance of a contracture and distortion of the part This type of closure and cervical contracture may be abolished

From a physiologic standpoint the simple direct skin incision is undoubtedly the best Some authors recommend the indirect or "beveled" skin incision Theoretically, the latter would seem to have certain merits But in practice unfortunately these are rarely realized The beveled incisions are much more difficult to close than the direct

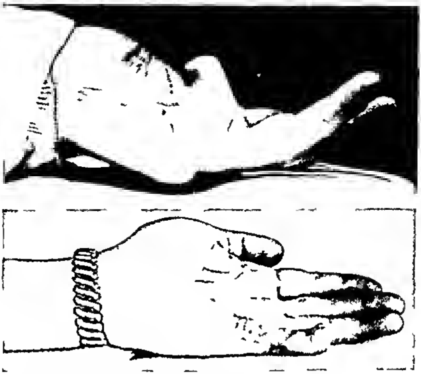


FIG 52 (*Top*) Fiddlestring' contracture of little finger (left hand) due to longitudinal incision of digit (*Bottom*) Same case, 5 months postoperative Correction by double 'Z" plasty

results in what is known as multiple 'Z'-plasty (Fig 36 *right*)

One of the most common sites of minimal contracture and maximal distortion of tissues in World War II was the rampant use of the ill advised vertical suprasternal incision for tracheotomy (Fig 54) The repair of these scars both for qualitative as well as quantitative reasons was a nuisance problem The proper secondary repair of such an approach necessitates relatively extensive dissection of the skin and subcutaneous tissue of the lower neck, in order that the difficulties of tracheal tugging ones of the conventional type There is also much to be desired from the standpoint of healing in this type of incision

On the premise that an abrasion reaching only through the thickness of the epidermis frequently heals with almost no evidence of injury, the hypothesis is put forth that an incision of like character should give the best cosmetic results All manner of beveled and indirect incisions have been attempted by various authors, but with results falling short of expectations H Lyons Hunt, who claims authorship of the 'oblique" incision, has even designed a knife for the purpose

By making a beveled incision it was felt that the wound in the epidermis would not overlie directly the wound in the derma and therefore the resultant surgical scar should be of a quality comparable to the ordinary superficial accidental scratch This of course does not take into consideration the additional trauma inflicted upon the delicate anatomic mosaic pattern of the skin the uneven curling and the retraction of the two lips of the epidermal phase of the incision and the greater difficulty of apposition of the edges

I have taken occasion to try all types of beveled incisions and have come to the conclusion that in actual practice they cannot compete with the simple direct old fashioned type of approach There are several reasons for this First of all a beveled incision implies a certain amount no matter how minute of undercutting of the epidermis This, in thicker skins results in the necessity of suturing the epidermis separately from the derma It also necessitates the insertion of a greater number of sutures both into the derma and the epidermis whose total increases the amount of foreign body to a point where postoperative tissue reaction is far more severe than in the conventional transcutaneous approach Secondly where the epidermis is very thin the dermis sutures have a tendency to slough through quite frequently Thirdly where the beveling of the incision is very obtuse the incision actually results in undermining of the epidermis wherefore as healing progresses there is a tendency for the undermined epidermis to pigment in the same fashion as an epidermic graft This results in a condition more obvious than the presence of a minimal scar There is as yet no substitute for the conventional type of skin incision

Fig 53 Circumventing straight line closures Illustrating condition immediately after repair of deep linear laceration of right cheek from corner of mouth to mandible Note breaking up of laceration by radiating small incisions so as to avoid straight line scar which would pull the corner of the mouth outward and downward

Management of Skin Edges

Though the importance of protecting tissue exposed by surgical incision is generally taught and accepted, paradoxically the skin is too often the exception to the rule It is not unusual in an operating room to see all care exercised with reference to tissues other than the skin but little or no attention paid to the hygiene and the protection of the skin itself In fact the lips of a wound are frequently used as a medium of traction anchorage or repository for every conceivable type of instrument or used sponges Constant tugging and pulling to augment exposure of the operative field is a regrettable technic There is no question but what this kind of thing is a major factor in determining the type of postoperative scar Hypertrophic postoperative scars are not infrequently the direct result of superfluous surgical trauma to skin and subcutaneous tissue If as much compassion were shown the latter as is exercised in the handling of the peritoneum good postoperative scars would be the rule rather than the exception

There are many ways of protecting the skin edge The simplest is the best This

the protection of the lips of the surgical wound Where for the purposes of appearance any changes are made it should be in the overlying towel rather than in the underlying gauze

In relatively short incisions it is not practicable to cover skin edges according to the foregoing plan but it is almost always possible to cover them at least with two or three layers of saline moistened gauze

As concerns the handling of the lips of the incision whatever instruments are employed for holding or retraction should be light fine hooks or smooth well plated retractors kindly used Whatever time and efforts are expended in the protection of the lips of a surgical incision will be adequately compensated for by the quality of the postoperative scar

Types of Tissue Dissection

Dissection is the purposeful separation of tissues There are two methods of dissection the sharp and the dull Sharp dissection implies the use of a scalpel whereas dull dissection implies the use of the scissors the gloved finger of the surgeon or such other instruments as do not actually cut but separate tissues by actual tearing Dull dissection is the laceration of tissue pure and simple no matter what instrument is used The accurate snipping of tissue with very sharp scissors on the other hand is nearer actual cutting than separation attempted with a dull knife particularly if the latter is guided by a heavy hand The quality of the instrument rather than its name plus the manner of its use is as important in determining the type of dissection as the instrument itself

Sharp Dissection The two types of dissection differ markedly in their physiologic implications Sharp dissection is the least traumatic the most accurate but it is more painful it involves a greater loss of blood and lymph and it is more dangerous to nerves and blood vessels These peculiarities of sharp dissection are due to the fact that the surgical trauma is very acute and minimal As a result of only microscopic injury of tissue there is practically no collapse of blood vessels or maceration and retraction of the intima Hence the factors conducive to rapid coagulation of blood and closure of blood vessels are minimal The absence of stretching of fine nerves as in the case of dull dissection which serves as a form of momentary analgesia the lack of retraction or covering of nerves by macerated tissue leaves nerve endings exposed and vital for longer periods of time during the operation than is the case with dull dissection On the other hand the wound is much cleaner physiologically the tissues are left in more normal microscopic relationships and therefore healing is much more rapid and accurate provided that all oozing is controlled before closure

Dull Dissection In dull dissection there is less bleeding due to more maceration of tissue collapse and retraction of blood vessels There is more blind trauma to distant and even collateral tissue due to stretching pulling and tearing Hence healing is more protracted and there is more fibrosis

The choice of the type of dissection depends upon the nature and the position of the defect the nature and the quality of the tissues the purpose and the plan of the operation and the ability and the habits of the surgeon Neither type of dissection can claim priority or exclusive routine application

Cleavage Dissection

Notwithstanding a mutation of the two types of dissection embodying the virtues of both is possible This results in a more physiologic and surgically cleaner procedure It may be identified as cleavage dissection The sharp scalpel is pre-eminent in this type of work

This kind of dissection is not easily applicable where lines of cleavage do not exist or where they have to be disregarded as in the presence of malignancy or where ex

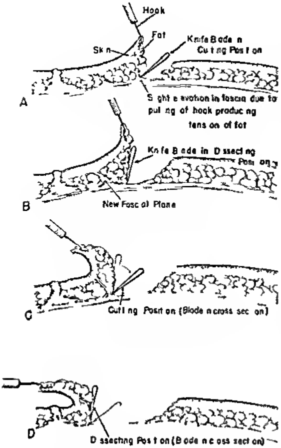


FIG 55 Cleavage dissection (sagittal views) (A) Allocating line of cleavage between subcutaneous fat and deep fascia immediately after skin incision knife blade at 50° angle (B) Angle (5° to 10°) of knife blade at moment of peeling fat from fascia (C) Rotation of knife blade to 50° angle at moment of meeting resistance of new facial plane (or scar tissue) (D) Vertical rotation of knife blade to continue cleavage dissection (See Fig 56)

tensive and unusual patterns of fibrous tissue are present In such instances cleavage lines are so obscured or tissue relationships so disturbed that only sharp dissection or outright guillotining of tissues is to be relied upon for good progress unless the surgeon is willing to risk by dull dissection and tearing complete disorientation and possibly severe injury to tissues it is the purpose of the operation to preserve

Cleavage dissection is based upon the principle that tissue with normal lines of cleavage needs only anatomic separation rather than actual cutting In a sense they are minute potential tissue spaces Spaces cannot be cut in the strict sense of the word Whereas cleavage dissection is normally applied to gross anatomic problems such as the separation of one fascial plane from another or one muscle from another it is seldom applied with consistency and skill in minute detailed dissection Nevertheless the principle should be applied in physiologic surgery

The method is a compromise between sharp and dull dissection It is dictated by the fact that an actual cut or incision is necessary only in the allocation or the creation of a line of cleavage Once that has been established easy separation or peeling of one tissue from another or one layer of a tissue from another is sufficient until a new line of cleavage is encountered or necessary Cleavage dissection never must be attempted with anything but a sharp scalpel

If one now chooses as an example the making of a femoral single pedicle flap, the actual procedure for purposes of illustration would be as follows a sharp incision is made to the depth where cleavage dissection is to begin in our case only to the level of the deep fascia (Fig 55) This must be very accurately identified in the depth of the incision before proceeding further The admonition applies to any tissue at the level of which cleavage dissection is intended to begin

A section of the lip on the thumb side of the operating hand is then picked up with two hooks The length of section of the lip between the hooks should only be such that when they produce a longitudinal pull upon the tissue the tissue will form a straight line between the hooks This is important because a scalpel is most accurate and efficient only when projected in a straight line Since this type of dissection is of almost microscopic exactness most evident expo-

sure of the line or level of dissection is necessary In other words, the eye must be consistently in touch with the sharp of the blade

The blade of the scalpel, in the case of the femoral flap, is then placed accurately under the upper hook at the level where the subcutaneous tissue meets the fascia The blade is first posed at a 90° angle to the fascia At the same time the flat of the blade makes pressure against the subcutaneous fat, for the purpose of slight stretching and exaggeration of the line of cleavage existing between the fatty tissue and the fascia At that moment, the blade of the knife is tilted about 60° clockwise The sharp edge of the knife is now in an incisional position with reference to the line of cleavage Slight pressure at this moment will begin to open up the line of cleavage At that moment the blade is quickly turned anticlockwise about 40° and sufficient sidesweep is made with it so as to peel the subcutaneous tissue from the underlying fascia The actual extent of sidesweep possible with the knife blade depends upon the consistency and the integrity of the subcutaneous tissue The knife blade constantly and accurately follows the receding subcutaneous tissue as the tissue is being peeled away from the fascia Constant pressure must be maintained against the fat by the instrument This will be found not only necessary but advantageous in that the operator s hand through constant pressure against the fat, actually feels the difference between the consistency of it and the underlying fascia This is a determining factor of the rapidity with which the procedure is executed At the same time it will transmit to the sensitive hand additional information as to the presence of fibrous septa, scars, nerves, blood vessels and other tissues which, when encountered in the depths of the cleavage line, necessitates immediate rotation of the knife blade either into a more cutting position in the case of the fibrous tissue or a more obtuse position in the case of nerves or blood vessels, so as to obviate injury to the latter

In the case where the knife blade meets with a new fibrous septum, it is immediately turned into a cutting position (angle of incidence to deep fascia of 30°) At that moment the fibrous tissue can be smartly and deftly guillotined The knife is again quickly rotated into a more vertical position and the sidesweep peeling motion is resumed

With a little practice and concentration it will soon be discovered that the sweep of the knife will only be deterred by the normal anatomic septa in the lines of cleavage or by fibrous tissue It is at these moments, palpable in the index finger of the knife holding hand that the instantaneous clockwise rotation of the knife blade changes the latter from a relatively dull dissecting instrument to one of acute sharpness The moment the fibrous septum is sprung, the blade is again turned counterclockwise so the flat of the blade pushes against the fat and further peels it from the fascia to the next palpable point of resistance

The entire maneuver of course, in actual practice occurs with such rapidity that the cutting the peeling and the various rotations of the instrument are seemingly executed in one continuous motion The behavior of the knife blade may be described as a kind of palpate cut peeling procedure With practice this experience of palpation at the blade end of the scalpel will be found to be quite consistent with the anatomic composition of the tissues In other words, before one cuts again one has already identified the kind of tissue which probably stands in the way An artery has a different feel from a fibrous strand, even under the blade of a knife

The foregoing is a kind of "slow motion" description, but as soon as one has learned how to palpate with the blade end of a knife, the various phases of the procedure will become as one continuous act It is not impossible to acquire certain skill in this

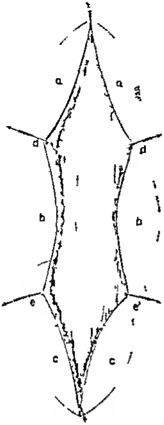


FIG 56 Cleavage dissection (rhythm of undermining) Zones a b c and a b c are zones of initial undermining Zones d e and d e are zones of secondary sweeps in undermining to mobilize small areas of contact between fat and fascia remaining about hooks (See Fig 55)

method by making a two- or three inch cut through the skin and the fat of a ham and then dissect this from the underlying lean substance

Reverting to the original problem of a single pedicle flap when the first section of the wound lip has been dissected away from the underlying tissue as far as convenient it is allowed to rest A second section of the lip is then splinted into position by leaving the original proximal hook in place and moving the upper one to a position below the former again to a distance consistent with a straight line when pulling on the hooks (Fig 56)

This maneuver is repeated until the entire lip of the incision is dissected away from the underlying fascia to the necessary lateral distance

If it is desired to mobilize the other lip of the incision the operator simply changes hands if he is ambidextrous or position with reference to the incision if feasible or places with his assistant if he cuts with only one hand Since most surgeons dissect with only one hand conveniently the change of place with the assistant will be found more appealing

With constant application this method eventually gives one the feeling of dissecting with a sharp and sensitive finger rather than with a blind instrument Its ultimate value is apparent particularly in very extensive dissections lasting over a relatively long period of time not only because every detail of the dissection has been constantly under direct vision and accurate palpation but because the tissues as a whole show no more trauma than one would encounter in gross elevation of muscle from its underlying structure for example Any method which is under constant positive control and produces a minimum of tissue trauma is a good method

SIGNS OF TISSUE TRAUMA

Trauma whether accidental or surgical results in certain immediate as well as delayed consequences The immediate clinical manifestations were discussed at the beginning of this chapter

The delayed clinical manifestations of surgical trauma are those signs which appear later in the course of the operation and are categorically referred to by Burian as signs of local shock Sooner or later in the course of a long operation these signs do appear The time of their appearance varies not only from individual to individual but from tissue to tissue in the same

individual Their appearance depends upon many factors such as tissue susceptibility to trauma the general condition of the patient types of instruments used their manner of application the handling of the tissues including manner of sponging age and sex of the patient and the presence or absence of scar tissue

Local Tissue Shock

One of the first signs of local shock is a sudden dryness of the surgical wound associated with loss of luster and transparency of the tissues If *oozing* is still present at that moment a more rapid coagulation of blood will be observed The latter as a rule precedes the onset of the general dryness This is followed by an apparent shrinkage of the wound as a whole associated with a certain loss of elasticity of the tissues The tissues seemingly begin to creep into the surgical field so that it is more difficult to keep them in retraction This is due to an acute tissue edema The tissues in the wound finally become boggy darker and more friable This friability will be manifest when picking up units of tissue with forceps or in passing sutures The sutures will begin to cut through with relative ease even while being tied If ligations are attempted within the wound they will not hold as before If it is decided to close the wound it may be noticed that the tissues are difficult to pull together and to approximate This is due to the effect of the acute local edema upon the normal elasticity of the tissues In the approximation of tissues with sutures pulling out it will be found that there is little oozing from the lacerations The appearance of the tissues due to a local neurocirculatory failure is not much different from severely lacerated or crushed tissue and may very well be referred to as local shock

About this time the patient who up to now was in seemingly good condition will become pale quiet and if under local anesthesia truculent or even severe Soon he becomes irritable less co operative disinterested tired and at times complains of actual wound pain even though there is legitimate doubt in the surgeon s mind about such pain If the individual is under general anesthesia it is usually the anesthetist who first notices a sudden change in the general condition of the patient The latter s respiratory excursions may change the pulse becomes more rapid and at times somewhat thready the pupils dilate and in general the anesthetist does not feel that the patient is getting along as well as he should There seems to be *no reason* why the patient suddenly does not take the anesthetic well or why he should have taken a turn

If the operation is continued the wound suddenly becomes moist again the veins are markedly engorged and there is considerable oozing into the wound Only this time the *oozing* consists of blood much darker than at the outset of the operation the wound becomes more flabby beads of perspiration appear about the edges and the wound is surprisingly easy to retract as compared with a few minutes earlier The probability is that the patient is about to go into general shock

If at that moment the local procedure is stopped if hot saline packs are placed into the wound and if the tissues about the surgical wound are tightly compressed against the packs within three or four minutes the general condition of the patient improves The facial expression of the anesthetist will also improve He may even suggest that the operator continue Upon removing the hot packs a change will be apparent in the wound It will be brighter red in color dryer than heretofore more elastic and the venous engorgement will have disappeared

Every effort should be made at this time to close the wound or terminate the operation in some intelligent manner Should the latter course be impossible only the bare necessities of the operation must be at

tended to and the wound closed This is advised not only for the sake of the patient, who may survive notwithstanding, but because if surgery is continued one can anticipate some degree of postoperative trouble in the wound This may take the form of bleeding or serous discharge into the wound, resulting in a so-called seroma, focal necroses gangrene or disruption of the wound to some degree or in toto In any event, healing will be more protracted This variable focal response of tissues to surgical trauma should be a signpost of the limit of tolerability to further dissection It is for this reason that only a given amount of reparative surgery in a given area is permissible at any one time if consistently good results are to be realized

The signs of surgical trauma enumerated above are only the physiologic signs of warning that the local tissues have reached the ultimate of tolerance and are prepared to share their suffering with the patient as a whole who if unable to compensate for the local injury may go into general shock

The problem of general shock is considered to be more relevant to the question of gross accidental injury and is therefore discussed in Chapter 15 Original Repair"

CLOSURE OF A SURGICAL WOUND

Deep Closure

Adequate closure of a surgical wound should be a planned operative procedure only second in importance to satisfactory accomplishment of the object of the operation It is a regrettable habit to slam the door shut on a well executed operation A poor closure is a local physiologic defect which may produce irreparable deformity or eventual invalidism The clinical toll due to injudicious closure of surgical wounds, not only from the standpoint of appearance but function as well is still of common enough occurrence to merit description in the light of modern surgery

The closure of a surgical wound should be done as carefully as the closure of a serious accidental wound First, the operative wound should be scrupulously clean This is best accomplished by irrigation with warm saline and gentle but thorough sponging of the incision This removes a great deal of microscopic and chemical detritus which would otherwise act as a foreign body material The wound should then be as thoroughly inspected as any accidental wound for tissue tags, untied sutures, oozing foreign bodies, such as strands of cotton or other suture material, and for dead spaces Obviously devitalized tissue should be debrided untied sutures removed and replaced, and dead spaces obliterated The last must be done without tension

The incision should be re irrigated and dried again Only then is it ready for closure Layer to layer approximation is the best form of repair and should be done with as few well placed sutures as possible These should be tied with only sufficient tension to bring tissue layers into apposition This is imperative because there is always a certain amount of postoperative edema in every surgical wound, which not only helps further to approximate the tissues but also increases tension upon sutures snugly tied This edema superimposed upon a tight suture is sufficient to result in local tissue ischemia, necrosis and sloughing of the suture material before the tissues have had the chance to coalesce

In a layer to layer closure the various suture lines should be so staggered where possible as to avoid superimposition Where this is not practicable without further dissection or undermining, the same objective can be accomplished by making certain to place the different sutures in various tissue layers at different distances from each other as compared with the immediately underlying layer so that the sutures of one layer do not superimpose exactly upon those of the previous layer (Fig 57) For types and the kind of suture material to be employed

in the apposition of specific tissues, see Chapter 13, 'Sutures and Suturing

When the depth of a wound consisting of muscle fascia and subcutaneous tissue has been properly closed the final step consists of the meticulous apposition of the skin edges Specific closure of accidental wounds is discussed in Chapter 15 Original Repair

Skin Closure

General Considerations Skin closure in surgery is commonly looked upon as a menial and more or less unimportant task to be turned over to the interne Whereas this opportunity for the trainee should be encouraged the homely spirit in which it is so often done is not to be recommended It is a false compliment to one s assistant It is poor technical training for him and unfair to the patient Sensible closure of skin incisions has been neglected to a point where the very simplest of fundamental surgical principles are frequently disregarded This surgical nonchalance is passed on from master to pupil with the unavoidable end result that the habit gets into the young surgeon s blood to where he later applies the same type of technic to the suturing of all tissues In reconstructive surgery at least skin closure is a distinct surgical concern demanding finished technic

The orthopedic surgeon takes great care to align properly the two ends of a fractured bone The neurosurgeon exercises great caution in meticulously suturing severed nerves The general surgeon takes time and care in repairing a cut muscle bundle to bundle, knowing full well the penalties for doing otherwise Yet little of this is applied to the closure of the homely skin hence, the frequency of unwelcome scars

The basic surgical principles of proper tissue approximation apply to skin closure as well as to any other tissue To avoid extensive postoperative scarring or diastases, the various layers of the skin should be brought together as accurately as pos

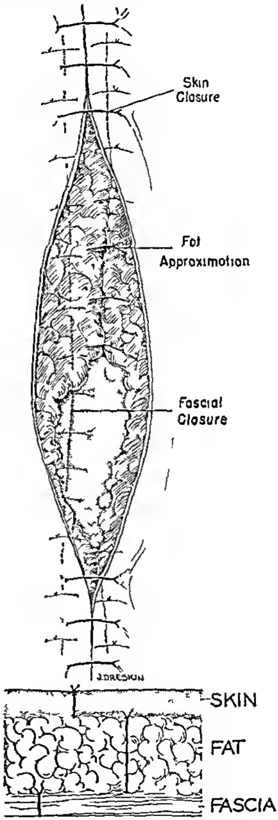


Fig 57 Staggering of suture layers

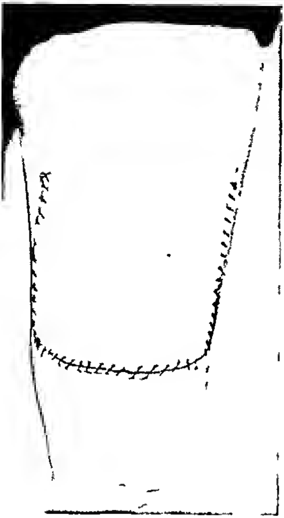


Fig 58 Accurate skin closure with continuous running suture (delay of single peduncle flap)

sible Derma should be apposed to derma and epidermis to epidermis on as accurate a level as is practiced in the alignment of fractured bone or the approximation of severed nerve ends This does not necessarily mean that separate sutures must be placed into the various layers of the skin This can very well be accomplished by the accurate placement of an individual suture which embraces the entire thickness of the tissue The accurate closure of the covering tissue of the body is important not only in avoiding hypertrophic scars or keloids but in expediting early healing (Fig 58)

Methods of Skin Closure A skin incision may be closed in one of three ways by adhesion, by coarctation or by coaptation

By Adhesion The closure of skin wounds by adhesion is a rather recent development in surgery It is the result of the constant striving for easier, more rapid, more ideal methods of skin repair than by the use of the suture Sutures, of course, have to be first inserted, then removed, which is very time-consuming and, being foreign material, they leave evidence of their presence It is therefore enticing to contemplate the possibility of skin closure without the use of sutures As a matter of fact, the sutures are only a temporary expedient necessary to bridge the time until actual biologic adhesion occurs

Closure of skin wounds by adhesion is accomplished through the use of biologic glues Such a glue is made by the precipitation of fibrin when thrombin is added to plasma The precipitated fibrin acts as the adhesive agent, holding the edges of the skin apposed The rate and the quality of the fibrin formation can be controlled by increasing or decreasing the concentration of thrombin solution added to the plasma

Forrest Young and Benedict V Favata report enthusiastically on this form of skin closure They employ thrombin prepared according to the method of W H Seegers by Parke, Davis & Company They feel that adherence of wound edges and surface can be readily accomplished by the use of plasma and purified thrombin The fibrin fixation artificially produced in this way has less tensile strength than ordinary suture material and for this reason use of plasma thrombin adhesion of wounds should be limited to those in which tension does not exist * The original work in this field was done by Machfeld F Sano of Temple University

* Young F., and Favata B V "Suture" of wounds by plasma thrombin adhesion War Med 6 80-84 1944

The production of the biologic glue is a comparatively simple procedure which can be done with the patient s own blood at the time of an operation It is better to draw the blood for this purpose at that time than to do it the day before since certain chemical changes occur in it within 18 hours which reduce the chance of a successful glue

About 5 cc of the patient s blood is withdrawn from his vein into a 10 cc container The aspirating syringe should contain 1 mm of heparin and 1 cc of Tyrode s solution Tyrode s solution consists of sodium chloride 8 0 Gm potassium chloride 0 2 Gm calcium chloride 0 2 Gm magnesium chloride 0 1 Gm sodium acid phosphate 0 05 Gm sodium bicarbonate 1 0 Gm glucose 1 0 Gm with distilled water to make 1 000 cc. This is filtered through a Berkefeld W

The contents of the syringe are then transferred to a centrifuging tube which must be properly balanced This is then centrifuged for about 15 to 20 minutes During the process the cells fall to the bottom leaving the plasma at the top Between the red cells and the plasma one finds an accumulation of a layer of white cells The plasma is then drawn off and placed into another container The layer of white cells is later pipetted off and placed into still another tube into which has been placed about 1 5 cc of Tyrode s solution and some glass beads Both of the aforementioned tubes should be kept cool One now has enough material for covering a surface approximately 80 square inches

When the white cells have been well shaken the plasma is painted onto the recipient area as a very thin film In grafting the raw surface of the graft is painted with the cell extract and apposed to the recipient site with some pressure Almost immediately (40 seconds) adhesion begins

A reaction takes place between the cell extract and the plasma The prothrombin of the cell extract by coming in contact with the plasma is converted into thrombin The thrombin then acting upon the fibrinogen of the plasma converts it into fibrin It is this fibrin matrix which acts the part of the glue

This same procedure is carried out in principle in its application as a biologic material for apposition of skin edges in other words as a biologic glue The most enthusiastic workers in the field originally were J Z Young P B Mebawar Tarlov Benjamin and their co workers Their work on nerve suture with thrombin plasma glue was mostly in the experimental field on rabbits They used autologous untreated plasma and concentrated autologous muscle extract The tensile strength of the clot seemed to depend upon the fibrinogen content of the plasma but the clot formed very slowly and their success with nerve suture ran about 30 per cent By adding thrombin to the plasma it was found that the clot formed more quickly and was more reliable

Not until Mellanby in 1933 made thrombin available in relatively pure form and until Seegers Warner and Smith had standardized it was further progress possible in the production of so called biologic glue material Tarlov then found that very satisfactory clots could be produced by the use of human fibrinogen and thrombin An inadequacy in the latter was that a certain degree of lysis occurred within 48 hours

Thrombin may now be procured from Parke Davis & Company as Thrombin Topical This is dissolved in an appropriate amount of saline (1 to 25) and if added to 4 times the volume of plasma it will result in the clotting of fibrin in 36 seconds Stored plasma can be used with good results

In the use of the plasma thrombin method as wound suture material the skin edges of the wound may be flushed with plasma which need not necessarily be autologous I have found that it is advisable to moisten only the very edges with

the plasma rather than to use too much of it, since the latter practice will result in a gelatinous mass which on contraction leads to an undesirable amount of weeping and at times the formation of thick scabs

The thrombin in the form of a white powder is dissolved in sterile isotonic so dium chloride solution, and the latter is sprayed by syringe into the wound which has already been painted with plasma The raw surfaces or skin edges, must then be quickly adjusted, the one to the other, and held very accurately and steadily in apposition for about two or three minutes Ad hesion actually begins in less than one minute, but one must be exceedingly careful not to permit the skin edges to move during the manual splinting, or the adhesions which form will be inadequate, or the apposition becomes distorted The tensile strength of the clot at this time and for probably 100 hours thereafter, in my expe rience is not sufficient enough to be reli able It is therefore necessary for about 4 to 5 days to splint the wound by some means other than the above in order that adequate organization of the closure be assured This is particularly necessary where any tension on the wound edges is anticipated or where some movement of the repaired part is un avoidable Traumatized tissues are seldom without tension whether that trauma be accidental or intentional

Notwithstanding this is an interesting complement to though not actual replace ment for the inorganic suture As yet it seems to me only adequate enough for relatively small incisions and small wounds In anything but a small straight incision it has been my practice to complement the above by a few judiciously placed sutures which are removed in from 36 to 48 hours Another complementary method is by the use of collodion strips placed over the incision or the laceration This is particularly true in the use of plasma thrombin for the apposi tion of skin grafts to the recipient area Some authors are very enthusiastic about the exclusive use of the glue Nevertheless, I have found that it is safer to use a few sutures approximating the graft to the edge of the recipient area at predetermined points, because in thick skin grafts there is always tension due to shrinkage of the graft as well as retraction of wound edges Some surgeons attempt to avoid this by cutting the graft from 10 to 20 per cent larger than the recipient area Unfortunately, the exact amount of shrinkage of a graft or the retraction of wound edges cannot be calculated, it can only be estimated Generally, the thinner the graft the greater is its shrinkage The younger the patient and the more elastic tissue in the skin, the more retraction there is of the wound edges In the consummation of the two, the tissue tension about the incision or the laceration becomes such that the fibrin thrombin clot will be found to be inadequate Consequently, some complementary form of splinting of wound edges or the graft to its recipient edge, as the case may be, is the safer procedure Finally, the advice that grafts be cut from 10 to 20 per cent larger than the recipient site seems to me to disregard the principle of tissue cost, which cannot always be afforded by the patient or risked by the surgeon and as a general rule should be avoided wherever possible The problem is discussed in further detail in Chapter 16, "Grafts and Grafting"

Notwithstanding the above is an ingeni ous and promising addition to the surgeon s armamentaria and with further refinement may aid in a more physiologic closure of wounds For the present it cannot be con sidered as a complete substitute or replacement for other forms of skin closure

By Coarctation Coarctation is a method of closure by extraneous pressure against the lips of an incision or laceration This may be accomplished in one of several ways (Fig 59)

One of the most satisfactory methods consists in the use of collodion strips Depending upon the length of the incision and

somewhat upon its location, strips of *bandaging* gauze of predetermined length and adequate width (usually from ½ to 1½ inches), are cut and placed at right angles to the incision All the ends of the strips on one side of the incision are then securely glued to the skin While waving one hand over the collodion soaked strips so as to expedite evaporation, enough time is allowed to elapse in order that the gauze becomes securely glued to the skin The lips of the wound are then held in apposition by the assistant, or one strip is chosen at a time by the operator and held tense so that the secured lip of the incision is apposed to its mate Thereupon the still free end of the gauze is glued onto the second lip with collodion When the latter has dried completely the strip above or below the first is glued down next, and so on until complete apposition of the surgical wound is secured

Sterilized adhesive tape may be used instead of collodion strips although the former is not as desirable or dependable Many other ingenious ways have been devised, such as the use of elastic rubber bands anchored to strips of adhesive running parallel with the incision hooks or buttons preoperatively adjusted to strips of adhesive which is then applied to both sides of the incision and the hooks laced across the surgical wound with silk or some other material The above are unreliable as compared with collodion strips, because adhesive has a tendency to creep, especially in hot weather The others are prone to result in inversion of the skin edges

The most recent and rather ingenious device in connection with closure by coarctation is the so called traction dressing of W James Gardner and V B Seitz, devised during the Solomons' campaign in the Pacific in World War II (Fig 59)

It is based upon the elastic traction of latex anchored to two spurred metal plates and is described by the authors as follows

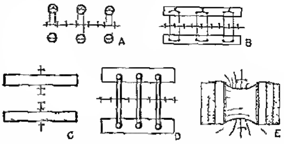


FIG 59 Types of coarctation (A) Wire through cottons (B) Wire through lead plates (C) Collodion strips (D) Rubber bands on hooks (E) Constant traction (C T) dressing of Gardner Seitz trade name Tractaclip

by a sheet of latex The metal members are fabricated from a sheet of stainless steel 0 004 inches thick The spurs on the metal members are 0 02 inches in length short enough so that they penetrate only the tough stratum corneum and do not cause pain bleeding or inflammatory reaction The spurs are very sharp and are set 1/20 of an inch apart The single rows of spurs can be attached to the skin close to the wound margin so that there is little tendency for inversion of the skin edge The metal members are all 1 inch wide but the elastic portion is made in various lengths for wounds of various sizes Shorter dressings may be applied as the approximation of the skin edges proceeds If properly applied the dressing will not come loose until the wound is sufficiently narrow to release the traction which keeps the spurs buried in the stratum corneum However, contact of the latex portion of the dressing with wound secretions for 4 or 5 days does cause some reduction in its elasticity "

I have used the constant traction dressing on several occasions In mechanical principle it is simple and ingenious It differs from the skin clip in that it approximates much more tissue and only penetrates the epidermic layer of the skin Though it is mechanically adequate and efficient as a coarctation device, physiologi

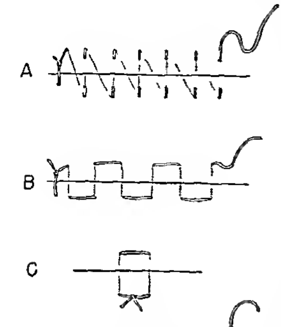


Fig 60 Methods of coaptation (A) Running or continuous suture (B) Running mattress suture (C) Simple horizontal mattress suture (D) Continuous lock stitch (E) Individual single suture (F) Vertical mattress suture

Bottom figure illustrates summary coaptation Large inclusive suture to be removed on second or third day

cause it does result in sufficient irritation of the epidermis in thin skinned patients leading to more or less permanent scarring of the skin Nevertheless, for unexposed parts of the body it is a rapid and useful method of closure of relatively small incisions, provided that the skin is not overly elastic, in which case the lips of the incision tend to be overcrowded and occasionally everted or inverted, depending upon the deep structure of the wound

Closure by coarctation is usually practical in only short incisions or lacerations, say up to one and one half inches Incisions beyond that length are not suitable for this type of closure as a rule because there is danger of separation of the wound or inversion of the skin edges Even in relatively small incisions or lacerations, the latter danger exists when the dressings are applied because if they are placed too tightly over the coarcted wound, the lips can be displaced into the depths of the defect and separation will result To avoid this complication it is necessary to use a few subcutaneous or dermic sutures before applying the collodion strips or the adhesive tape If the dressing or the pressure upon it are not equally distributed on both lips of the wound, one lip may be pushed into the depths of the wound, whereas the other may remain everted, resulting in overriding the skin edges

By Coaptation Coaptation by some form of suture material is the conventional method of skin closure It may be accomplished by placing sutures subcutaneously intradermally, transcutaneously or by a combination of the three (Fig 60)

Subcutaneous coaptation of skin edges is usually accomplished by accurate closure of the superficial layer of the subcutaneous tissue The sutures in this case are meticulously inserted just under the derma in an inverted manner so that when tied the knot is buried in the depths of the subcutaneous tissue (Fig 61) In this type of closure some form of coarctation is fre

quently necessary to guarantee the approximation of the epidermis, which occasionally tends to retract

This type of approximation results in a very fine postoperative scar without any danger of the displacement of skin edges during the healing phase The success of it is predicated upon the presence of subcutaneous tissue of good timbre so that the sutures will *not* cut *through* the tissue before the lapse of 5 or 6 days Where subcutaneous tissue of that type exists the superficial layer of the superficial fascia separating the subcutaneous fat from the derma is well developed and therefore will permit of approximation without the danger of the sutures pulling out of the fat

The most common method of intradermic closure is the so called Halstead continuous suture This is more laborious than the former but very exact and results in the finest postoperative scars This method is conveniently employed in the closure of incisions or lacerations on the exposed part of the body (Fig 62)

The needle bites are taken directly through the upper substance of the derma itself and must be very accurately placed The bites should be just sufficient to bury the suture material in the derma If they are too generous when the suture is pulled tight so as to bring the lips of the incision into apposition, there is danger of puckering and spotty overriding of the skin edges One of the most important details in a well

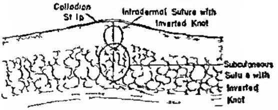


Fig 61 Subcutaneous coaptation with inverted knot (Note suture barely nipping underside of derma) Inverted knots are placed by projecting needle through tissue from bottom out when starting

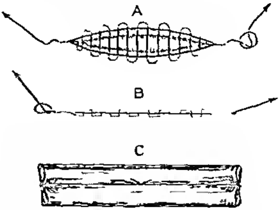


Fig 62 Halsted closure (A) *Point* of suture entry outside of incision with method of tying (B) Point of suture exit with method of suture anchorage to skin beyond incision (C) Manner of dressing of incision by tying suture ends over gauze

applied Halstead suture is that the opposing bite in the two lips be taken at exactly the same level in the derma or to put it another way at the same exact distance from the outer layer of the epidermis If this should vary so much as *1/32* of an inch overlapping or eversion of one lip as compared with the other will occur Since most suture needles are at least as thick as 1/32 of an inch, it is apparent that this type of suturing must be done with unusual patience and accuracy

Almost any type of suture material can be used for this purpose except chromic gut or cotton In my experience, these two are not well tolerated by derma and sooner or later tend to be excluded from an apparently healed suture line Finally cotton is not altogether dependable when being pulled out of the suture line, and fractures rather commonly This of course, can be a very embarrassing situation

Dermic closure of the suture line can also be accomplished by interrupted sutures but this is technically far more difficult than the continuous Halstead technic If it is attempted it is important, as in the case of the subcutaneous closure that the sutures

be so placed that the knot reposes under the skin or within the immediate subcutaneous tissue when the suture is tied (Fig 61)

The transcutaneous form of coaptation is the most common form of skin closure It can be accomplished either by interrupted or continuous suturing It is probably the most rapid method of closure and for lacerations or incisions in general it remains the most practical type (Fig 63)

Fig 63 Transcutaneous coaptation illustrating conventional type of closure and vertical mattress sutures placed over rubber catheters following excision of extensive hypertrophic scar (see also Fig 58) All mattress sutures should be tied loosely and removed early

The question sometimes arises which is the more nearly ideal the interrupted or the continuous form of closure Although each has its definite indications and specific applications in themselves they are not as important as the manner in which the suturing is actually performed This is discussed in detail in Chapter 13 Sutures and Suturing

All manner of material has been used for transcutaneous skin closure There is no ideal form of suture wherefore arguments pro and con are common The material used with certain definite exceptions is not as important as the technic of closure The advantages and the disadvantages of commonly used suture materials are discussed in Chapter 13, Sutures and Suturing

DECORUM IN THE SURGICAL THEATER

General

Little or nothing is said in textbooks about personal conduct and courtesies in the operating room Where proper courtesy is not reciprocal or proper conduct is wanting teamwork is impossible Without proper teamwork surgery becomes difficult

Aside from the importance of proper training of operating room personnel in the technical necessities of an operation nothing makes performance for the surgeon more impossible than lack of co operation Such lack may be the result of ill fitting personnel bad will lack of discipline the surgeon s temperament or the lack of appreciation of the operative difficulties by the personnel The atmosphere of an operating theater need not necessarily be that of a sanctum sanctorum but it is trying to do

adequate work in an atmosphere akin to that of a restaurant kitchen All personnel trained for and admitted to an operating room must be thoroughly conversant with the fact that surgery is not an occasion for foot racing but a serious incursion upon the safety, comfort and privacy of a human being where compassion, efficiency and respect must be the rule

An operation is a serious undertaking for both the patient as well as for the surgeon The seriousness of the event must be the law of the hour, courtesy and co-operation, the spirit of the occasion

Addressing Assistants

No matter how kindly disposed the surgeon may feel toward his assistants, while in the operating room, he should address them by their title Professional objectivity is preferable to friendly sentiments It may seem more democratic to address one's nurse by her first name or the assistant by his nickname, but it adds nothing to the atmosphere and the efficiency of the operating theater or to the dignity of the situation This is particularly so where the patient is being operated upon under local analgesia

It should not be necessary for the surgeon to have to command the operating room personnel, nor to have to cajole A simple and forthright request, preferably prefixed by the word "Please" should be sufficient for those assigned to an operating room to discharge their obligations Assistants who have to be ordered to comply with requests in the operating room are people who are temperamentally, emotionally or intellectually unfit to be there

Once the surgeon's request has been complied with, it is his reciprocal obligation to say "Thank you" It is a simple form of recognition of the individual and easy manner of immediate commendation It goes a long way toward the establishment of proper professional relationships and dignity This "well done" attitude on the part of the surgeon is a form of compensation particularly necessary with the novice in the operating room

Since most operations in plastic surgery are done under local analgesia, propriety of conduct and conversation among the personnel is all the more important The mental peace of the patient is influenced in no small way by the general peace of the operating room

Conduct of the Aids

It is very disconcerting to the patient, as well as discomforting to the surgeon to have to tolerate careless transferring of supplies and operating room equipment Young children are particularly frightened by such things, and therefore every effort should be made to employ proper precautions in conduct and exercise of duties Unnecessary whispering, conversation or discussion of the patient, the operation or personal problems must be discouraged Patients with eyes covered hear far more acutely than one would suspect Proper surgical decorum should be maintained until the patient has left the operating room

Once the operation is finished, the patient should be relieved of his coverings as systematically and as kindly as when being draped for the operation It is not good practice for members of the surgical team to go into a kind of frenzy of disposal of the patient, by the banging of doors, pushing of stools, sudden jerking of sheets from the individual, unstrapping, bumping of carts against the operating table and without much warning pulling the patient onto the cart as if it were an emergency to get rid of him The patient should be wheeled out of the operating room with the same care, caution and quiet attention as when he was received

The Surgeon's Exit

The surgeon never should depart from the operating room without proper observance of those who were most helpful, as

well as a word of direction to such as need it He never should un nap his gloves throw them into a corner, drop his gown into an other which may already have been cleaned for the next operation and seemingly leave with an air of little appreciation for the efforts of others He should depart from the operating room with the same care, courtesy and manner as he would from the home of a friend

BIBLIOGRAPHY

Allen E C and Eversole U H Use of curare in anesthesia New England J Med 236 523 194 Journal of Diagnosis and Treatment 15 61 1947

Allen F M Reduced temperatures in surgery 1 Surgery of Limbs Am J Surg (N S) 52 No 2 1941

——— The newer developments in shock and refrigeration J Internat Coll Surgeons 8 No 5 1945

An bro F P A method of continuous brachial plexus block Am J Surg 71 716 1946

Artz C P Martin M and McCleery R S Disadvantages of dicumarol with special reference to therapeutic inadequacies Am J Surg 77 4 1949

Beattie J Metabolic disturbances after injury Brit M J 2 813 194

Beck E C Adhesive plaster method for the rapid regeneration of skin over granulating wounds Ann Surg March 1919 p 291

Berry F B Surgical principles in wound management Bull New York Acad Med (2nd series) 22 605 1946

Besser E L Role of the adrenal glands in shock Value of desoxycorticosterone acetate in the prevention of operative shock Arch Surg 43 249 1941

Blaine G Experimental observations on absorbable alginate products in surgery Gel film gauze and foam Ann Surg 125 No 1 1947

Borchardt M Mastic glue for wounds Beitr z klin Chir 87 453 1913

Bressan P G The use of novocain intra

Bullard O K and Brockett S I Combined pentothal sodium nitrous oxide oxygen anes venously and intra arterially An paulist de med e cir 56 161 1945

thesia in oral surgery J Oral Surg 3 138 1945

Burian F Fysiologicke Operovani Knihtiskarna Tyrs us V Praze 1945

Chouke K S and Whitehead R W Wound healing with especial reference to muscle and fascia repair Surgery 9 194 1941

Conroy W A Anesthesia Chicago Med. Soc Bull 49 No 7 1946

Covell H D Anesthesia for radical neck surgery Ann West Med & Surg 2 457, 1948

Crossman L W Allen F M Hurley, V Ruggiero W and Warden C E Refrigeration anesthesia Anesth. & Analg 21 241, 1942

Dos Ghali J Bourdin J S and Guiot G Intravenous injections of novocain in dyspnea Bull et mem Soc med d hop de Paris 57 41 1941 also Presse med. 49 1210 1941

——— Intravenous novocain in dyspneas Rev de med Paris 60 31 1943

——— Intravenous novocaine in dyspneas Presse med 51 92 1943

Goodman J H J Meehan J and Frankel R Capillary permeability in relation to acute anoxia and to venous oxygen saturation J Clin Investigation 26 1119 1947

Grana F Anesthesia in war surgery J Internat Coll Surgeons 7 No 3 1944

Harkins H N A new type of relaxing incision —the dermatome flap method Am J Surg (N S) 59 1943 79 1943

Hazard R Present status of the physiologic actions of novocaine and its therapeutic applications Progres med 73 403 1945

Hildenbrand E J C Refrigeration in surgery J Internat Coll Surgeons 10 No 4 1947

Howes E L Cellophane as a wound dressing Surgery 6 426 1939

Jenkins H P Control of hemorrhage by gelatin sponge J Internat Coll Surgeons 10 No 5 1947

Jenkins H P Senz E H Owen H W and Jampolis R W Gelatin sponge for control of hemorrhage J A M A 132 No 11 1946

Jirasek A Uvahy o Chirurgii a Chirurgovi Uvodni prednasky klinicke z let 1927 az 1936 Praha 1937 p 155

Lawrence W H and Berry C H True rhythm in surgery Am J Surg p 393 Sept 1938

Lewison E F Rayable gauze as a factor of safety in surgical operations Bull Am Coll Surgeons 27 No 1 1942

Lexer Bevan General Surgery New York Appleton 1908 pp 47 133

Lustig B Goldfarb A R and Adlersberg D Distribution of proteoses and peptones after intravenous injection Proc Soc Exper Biol & Med 58 No 2 1945

Matas R International Text book of Surgery Philadelphia Saunders 1900 Vol 2 p 910

McDougal W Effect of parenteral saline solution on wound healing Am J Surg 71 312 1946

McMahon R G and Darby F U Fiberglas packs in pelvic surgery New Orleans M & S J 98 523 1946

Nicholson M J and Eversole U H Neurologic complications of spinal anesthesia J A M A 132 No 12 1946

Phemister D B Changes in bones and joints resulting from interruption of circulations Arch Surg 41 436 4 2 1940 41 1455 1940

——— Contributions of animal experimentation to the treatment of surgical shock Surg Gynec & Obst 86 No 4 1948

Pickett W J Refrigeration in surgery of the extremities Illinois M J 91 4 194

Pitkin G P Conduction Anesthesia Philadelphia Lippincott 1946

Preston D J The effects of sutures on the strength of healing wounds Am J Surg (N S) 49 No 1 1940

Sloan H P Physiologic abdominal incisions Am J Surg (N S) 45 515 1939

Slocum H C O Neal K C and Allen C R Neurovascular complications from malposition on the operating table Surg Gynec & Obst 86 No 6 1948

Solkow M L and Clements A B Pentothal sodium intravenous anesthesia A modification in technique of administration Anesth & Analg 21 1 8 1942

Straatsma C R Surgical technique helpful in obtaining fine scars Plast & Reconstruct Surg 2 No 1 1947

Tovell R M and Barbour C M Experiences with procaine administered intravenously Presented at a Joint Meeting of the American Society of Anesthesiologists Inc and the Anesthesia Section of the Los Angeles County Med Assoc Los Angeles April 10 194

Trifari L M and Martin S J Civilian and military aspects of intravenous anesthesia Anesth & Analg 26 45 1947

Uihlein A Clagett O T and Osterberg A E The use of oxidized cellulose for hemostasis in surgical procedures preliminary report Proc Staff Meet Mayo Clin 20 No 2 1945

Verkhovskaya E A Intravenous alcohol anesthesia Am Rev Soviet Med 2 No 3 1945

War Dept Technical Bull Local Anesthetic Agent TB MED 43 1 May 18 1944

Wiley H M and Sugarbaker E D An evaluation of abdominal wound closure steel wire layer closure compared with catgut silk layer closure early and late results Surg Gynec & Obst 85 No 1 1947

Wolfson S Intravenous procaine below tourniquet for surgery of the extremities Connecticut M J 12 932 1948

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13

Sutures and Suturing

The suture is to the plastic surgeon what the splint is to the orthopedist and what the intra oral appliance is to the orthodonist The suture is literally a microscopic splint and must be applied in that spirit, according to the principles governing all splints Therefore it should not be used to force tissues into position any more than a plaster cast is intended to reduce a fracture The suture like plaster is intended only to maintain tissue position In other words, a suture should splint a unit of tissue where it lies provided that the surgeon makes certain that it lies where it belongs

SUTURES

The variety of suture materials used in surgery is legion and ranges all the way from human or animal hair to various metallic wires

Cotton

In recent years much has been made over the use of cotton as suture material Various types of cotton are recommended, such as mercerized quilting and crochet cotton Mercerized cotton is chemically treated by caustics viz caustic soda quilting cotton is a material whose thread has been run through a starch bath crochet cotton is the ordinary sewing thread which for the most part is mercerized

In general the strength of the cotton varies not so much with the diameter of the thread as with the brand Cotton does have certain advantages It is easily procurable it is cheap and plentiful Once tied, it will stay tied much better than any other suture material It rapidly soaks up tissue juices during an operation and so adheres to the tissues, assuming their color and consequently is relatively difficult to see and to manage Other disadvantages of cotton will be discussed presently

Philip Thorek, of Chicago, makes a comprehensive report on five years' experience with spool cotton as a suture material He concludes that

> Cotton remains the suture material of choice after five years' experience with it in over 1,000 cases It makes for better technique and less tissue trauma Evisceration infection and drainage sinuses are less likely to occur with cotton sutures It is safer to get patients out of bed early with this suturing material, thus lessening postoperative thrombus formation and coronary complications Cotton is economic, easy to sterilize and standardize *

Thorek's report deals with cotton as used only in intra abdominal surgery His conclusions are admissible as far as they concern the internal use of cotton, but in the experience of the author in hundreds of cases where cotton has been used for skin and subcutaneous tissue revision, the conclusions cannot be said to apply to the same extent

Cotton is relatively irritating to the derma and is not particularly well tolerated by the epidermis itself In fact, it is my feeling that cotton, particularly for purposes of tissue reconstruction has been overrated and is not as welcome a material in plastic surgery as one would wish it to be It continually absorbs tissue juices, stays wet and frequently leads to microscopic macera

* Thorek P Five years experience with spool cotton as a suture material Am J Surg., 71 652 656 1946

tions about it This is followed by extrusion of the material interference with healing and ultimate suture pock marks

S A Localia* gives a comprehensive and informative day by day clinical report on the behavior of cotton

During the first 24 postoperative hours there is very little if any reaction to cotton In the second 24 hours there is some capillary reaction and polymorphonuclear leukocyte infiltration On the third day there is round cell infiltration with occasional polymorphonuclear reaction On the fourth day there is capillary budding about the cotton as there is about silk but not as pronounced a cellular infiltration as with catgut On the fifth day the sutures seem to be encapsulated and the acute reaction to the cotton appears to have ceased On the sixth and the seventh days the acute reaction to the cotton has entirely subsided

This account establishes one of the essential objections to the use of cotton in plastic surgery where it is common practice to remove sutures on the third or the fourth day Where wound irritation exists as a result of suture material there is always the question as to whether or not the incision will hold adequately enough Even if the incision per se does hold where there is any obvious reaction about the suture material the probability is that after the removal of the sutures the incisional scar will widen somewhat in comparison with what it was at the time of removal of the sutures This widening may go on for 6 to 12 weeks

According to Meade until the thirteenth day there is evidence of cellular reaction and very little attempt on the part of the fibroblast to infiltrate into the interstices of surgical gut sutures which is not the case with cotton Meade also found that when sutures were tested for tensile strength size for size catgut was the stronger This was followed by silk linen and cotton in that order

In spite of Localia s work there seems to be little to choose from where nonabsorbable sutures are concerned His points in favor of cotton and as against the short comings of other nonabsorbable material would not recommend the former over and above the latter It certainly cannot compare with the use of horsehair or fine stainless steel wire so far as tissue tolerance is concerned The last seem to be the kindest to all forms of tissues Nevertheless all things considered horsehair still remains the ideal suture for skin closure in plastic surgery wherever it can be employed This is due to its natural elasticity which is not possessed by any other known suture to the same degree the ease of handling and the nonirritation of tissues

Horsehair

Horsehair is relatively easily obtained easy to sterilize and to tie Because of its elasticity there is little danger of tying it too tightly The greatest objection to horsehair on the part of the general surgeon is that as a rule it is not strong enough for his purpose This is due to the fact that closures in general surgery involve relatively large wounds in patients whose general condition is not always the best and therefore the surgical incision of necessity must be closed with as little expenditure of time as possible This mitigates against exact layer to layer apposition of the tissues of the wound because such apposition is time consuming The result of this type of closure is that the over all postoperative tendency toward tissue retraction is of such degree that the skin very often has to carry more than its own share of the load Consequently the tension of the skin edges upon the suture material inserted is far greater than what it is in a plastic repair where normally each and every layer of tissue up to and often including the derma is accurately apposed Hence the only tension remaining upon the

* Localia S A Experimental and statistical stud es experimental observations Surg Gynec & Obst Sept 1943

——— Wound healing exper mental and statistical results Surg., Gynec & Obst Oct 1943

skin lips is its normal elasticity, which is relatively minimal In our case horsehair remains an adequate suture material

Notwithstanding one cannot escape the fact that from the standpoint of physiologic surgery any tissue which cannot be splinted in position with good horsehair without fracturing the suture material is undoubtedly under too much tension or subject to a traction load by deep tissue To put it another way a physiologic wound closure rarely calls for stronger material in skin apposition than horsehair

Horsehair is more easily managed postoperatively than most other forms of suture material Its identification is simple because of its color and its removal is very easy Postoperatively serum seepage does not accumulate about horsehair thus obviating the heavy scabs so common about cotton and silk When seepage does occur the extruded material does not cling to horsehair as it does to silk of cotton With cotton it always results in the matting of the suture material which sooner or later acts as a foreign body irritating the surgical closure sometimes to the point of necrosis

Silk and Catgut

Bower and Pearce * of Philadelphia came to the following conclusion in comparing silk and catgut when used for suturing mucous membranes

> Fine chromic catgut is more easily handled than silk of the same caliber The tissue reaction to fine silk in the mucosa resembles the reaction toward a markedly foreign irritant It is especially noticeable after 2 or 3 days when the unabsorbed silk produces pressure necrosis with sloughing of mucous membrane Wound healing of the mucosa is more rapid when fine chromic catgut is used Fine absorbable catgut designated as number 00 000 medium chromic having an average diameter of 0 006 inches has been shown to be superior to fine unabsorbable black silk of equivalent size (0 000 diameter 0 06 inches) as suture material for the mucous membrane of the stomach because the silk produces pressure necrosis at the site of insertion with subsequent sloughing as shown by redundant intraluminal loops *

My personal experiences with silk in such situations coincides with those of Bower and Pearce As a matter of fact, I do not think that there is very much to choose from between silk and cotton, although the latter is probably somewhat more irritating than the former Both, on the other hand are notorious for producing relatively much tissue maceration, even if tied loosely

Obviously, no ideal suture material is available as yet for all phases of surgery The solution of this problem remains a tantalizing clinical challenge and has led to experimentation with other forms of closure such as the coagulum contact method of Sano

COAGULUM CONTACT CLOSURE

I have used the coagulant contact method in 47 patients, involving a total of 49 separate operative procedures Ten of these were third degree burns 28 were accidental wounds and 9 were elective procedures The preparation of the Glue' is described under Closure of the Surgical Wound,' in the previous chapter

In one half of the cases, in each category, no sutures at all were used whereas in the other half of the cases a minimal number of sutures were employed so as to insure the geometric splinting of the graft with the outline of the recipient area

In the cases where no sutures at all were used 4 per cent of the grafts were totally lost In 8 per cent of these almost one half of each graft was lost and in 10 per cent of the above cases up to 1/25 of each graft was lost In the series where sufficient suturing was done to insure geometric splinting of the graft with the outline of the recipient area no total loss was sustained whereas in only 4 per cent up to one quarter of the graft was lost Finally in only

* Bower J O, and Pearce A E The superiority of fine catgut over fine silk as a mucosal suture in gastric surgery Surg Gynec & Obst 74 649 1942

8 per cent of cases was there partial loss of graft up to 5 per cent

The manner of application of the graft the dressing and the splinting thereof were the same in all instances An effort was also made to select cases so that the grafts in the two series were in comparable anatomic positions with grafts of the same ilk

It is my impression that the greatest danger in the use of the coagulum contact method without the use of sutures is considerable retraction of the grafts away from the edges of the recipient site This of course necessitates secondary procedures in a fairly large number of cases for esthetic reasons in order to satisfy the demands placed against corrective surgery

Nevertheless the method has certain merits There are situations where the time element the difficulty of application of the graft or the position of the lesion makes the coagulum contact method a desirable adjunct to plastic repair I do not feel that this method is entirely capable of displacing apposition by suturing

In comparing the two methods one must remember that they are basically different concepts in wound closure Even when used only for the everyday purposes of skin closure the two should not be confused though they may complement one another

As has been stated before the suture as such is a splint The implications of this are in contrast with the mechanism of the coagulum contact method of wound closure A suture s primary purpose is to maintain tissue in a position of rest without tension and to secure accurate apposition for a sufficient period of time to give nature an opportunity to react to the trauma and to initiate the healing process by generating its own fibrin glue This natural process is the only guarantee of permanent maintenance of tissue position and apposition Where this biologic process fails the wound will reopen spontaneously upon the removal of sutures This is not uncommon in electrical burns and certain conditions associated with avitaminosis I have seen such wounds reopen after sutures were kept in situ for 19 days

The suture has nothing materially to do in a positive way with the process of healing Of course it may influence healing in a negative sense but it has much to do with influencing collateral tissues in their relationship to formative healing through secondary or indirect splinting thereof

This healing through splinting is something the coagulum contact method cannot influence In fact it would seem that this element particularly as concerns plastic repair is disregarded The essential virtues of the coagulum contact method lie in the fact that it directly affects only the immediate conditions responsible for the phenomena of healing But it exercises little control over the collateral tissue mechanics and their effects upon wounds It has no influence upon tissue splinting retraction rest and replacement which are factors mechanically and anatomically important in the over all result In other words neither simple coaptation nor exclusive coagulum approximation of a surgical incision or an accidental laceration in itself constitutes sufficient ground for adequate healing of the wound They are interdependent

The veracity of this is borne out pre*eminently by the high percentage of scarred* cheeks seen after laborious suturing as compared with the often better results obtained by careful coarctation with collodion strips or adhesive without any suturing (Fig 64)

Whether a wound be closed by primary apposition or left to granulate it will be observed that in 3 or 4 days following the injury a tissue reaction collateral to the wound will make itself apparent for a variable distance from the lips of the laceration This is manifested by redness a certain degree of cutaneous edema discolorations of various sorts and occasionally blistering This reaction is invariably present in accidental lacerations and is an occasional accompaniment of surgical closure In the

FIG 64 Closure by coarctation (*Left*) Flak wound of cheek in aviator (*Right*) Results following closure of skin with adhesive strips (mucosa sutured) Note total abscence of suture marks and minimal scarring Although cheek is depressed and flattened formative revision is simpler than if suture coaptation had been used and resulted in deep suture marks (for final result see Chap 30)

latter case it is almost invariably due to accessive handling of tissues and tight sutures whereas in traumatic wounds it is a concomitant of the injury

This collateral zone of tissue reaction usually extends for a distance of about one quarter to one third of an inch lateral to the lips of a wound In badly traumatized wounds the zone may be quite wide It has a tendency to vesiculate retract invert bleed or even to slough unless properly splinted The coagulum contact has little if any control over this situation Only a well placed and sensibly tied suture or adhesive splint can secure and put to rest this zone of hyperemic tissue so that the cooling off process and reorganization of the normal tissue mosaic is expedited pressure dressings are most useful Unless such tissue is properly and adequately splinted a vicious circle results within 2 or 3 days consequent upon the traumatic edema and venous failure which leads to considerably more tissue fibrosis than if the tissues are immediately accurately and adequately reposed The closure of the wound per se is only one of several things which determines the quality of ultimate healing and repair

Therefore it would seem that some happy combination or compromise between the two methods that is proper and kind suturing and the coagulum contact method would be the better solution to the problem of closure The essential virtue of the coagulum contact method as contrasted with the inanimate suture is that the former supplies the vital principle to wound healing which always has been lacking in suture closure The purely physical adhesiveness of the wound or graft edges as the case may be resulting from the use of biologic glues is only a minor detail to recommend

it This phenomena can be produced as all know who have done sufficient grafting by simply using a certain amount of pressure over the graft for a minute or two particularly if this be attended by the application of a cold compress to the graft The graft very quickly adheres to the recipient site without the necessity for any kind of glue The difference in adhesiveness in the two methods is a matter of degree

TECHNIC OF SUTURING

Suturing is a delicate art It is a form of wound closure and splinting of collateral tissues It is accomplished by the repeated insertion of sutures at predetermined sites in and about the wound This is unavoidably attended by a certain amount of minimal trauma—the result of needle punctures and pulling of the suture material through the sensitive tissues The summation of all these minute injuries which a tissue must sustain during the process of suturing under certain conditions equals the maximum amount of injury which that tissue will tolerate

The basic concept of suturing of course is the establishment of optimal conditions for primary healing Such healing is desirable because it results in the minimum amount of scarring and the maximum of physiologic repair Because suturing deals methodically with small units of tissue it must be done with the most atraumatic instruments and with the greatest of care The placing and the insinuation of even a single suture involves a number of steps which in their total effect upon the unit of tissue involved are a relatively important traumatic factor

In the placing of a suture a unit of tissue must be picked up by an instrument and properly staged so that the needle may be projected accurately to the desired depth In traversing the tissue irreparable destruction of a certain number of cells occurs These are further traumatized by the pulling of the suture itself through the needle wound Its quality and the manner in which it is pulled through the tissue have definite influence upon the ultimate wound It is not uncommon to see a more than necessary amount of suture material often 20 inches in length pulled through a segment of tissue with such bravado that a local microscopic burn results The needle passed through the opposite side of the incision and followed by the long strand of material thus repeats the insult The unnecessarily long suture is then frequently rocked or sawed to and fro thus adding another factor to the extent of the suture burn This is a regrettable habit which has nothing to recommend it

The ends of the suture are finally and frequently pulled upon to an extent where overstretching of the tissues is followed by rupturing of its delicate constitution The suture material is often tied with such unconcern that constriction of the tissues which the suture embraces is sufficient to cause permanent injury to its neurocirculatory integrity The knot is not uncommonly placed right over or between the lips of the incision so that it immediately acts as a foreign body interfering with normal healing When all these factors usually begotten by habit rather than intent are repeated throughout the closure of a wound it should not be surprising that such a wound must struggle to heal

Strange as it may seem the proper technic of suturing is usually acquired by the young surgeon after several years of bewildering experiences and headaches Important as the problem of wound closure is not enough emphasis is laid upon the important details which enter into it No effort should be spared by the young surgeon in the early comprehension of what constitutes good suturing

A unit of tissue to be traversed by a needle and its attendant suture material should be handled as little as is consistent with accomplishment of the task Frequently the tissue to be perforated by the

FIG 65 Errors in suturing technic Although planning of closure following excision of fiddlestring contracture of antecubital fossa is a good one, suturing is in error because suture bites are too skimpy and knots are placed right over incisions (cf Fig 58)

needle does not have to be picked up at all If it is relatively stationary at a good angle to the operator and if the point of the needle is accurately and sharply set upon the epidermis an efficient whip of the wrist will accomplish the desired result When an instrument is used for the purpose of stabilizing the skin a relatively large section of tissue should be elevated by it and lightly posed In picking up more tissue than is actually needed for the traversion of the needle it can be more kindly and securely held with less pinching than if only the very minimum of the edge is grasped by the forceps Fine hooks are preferable to forceps The tissue being properly staged the needle is then very accurately set at the chosen point on the epidermis and whipped through the skin always at right angles to the surface It never should be wabbled or levered through the skin The hook or tissue forceps stabilizing the skin never should be used as an instrument of force to push the tissue over the needle, for this is poor technic.

All needles employed should be of the finest and most atraumatic design, consistent with the accomplishment of the task The sharpest needle is the most atraumatic for tissues difficult to perforate such as senile or thick skin, whereas the smooth round needle is the one of choice for use in soft tissues such as mucous membrane muscle or tendon

Once the needle has completely traversed the tissue the suture material attached should be carefully pulled through in such a manner that it does not drag the atrium of the needle perforation into the depths of the wound The length of the suture material should be consistent with the quality as well as the quantity of tissue which is being sutured For instance, in the approximation of severed nerves or the suturing of fatty tissue, the suture should be only long enough to serve the purpose of one tie In any case sutures never should be longer than 12 inches Once the length of the suture has been pulled through the two sides of an incision or a wound it should be rested In no case should it be sawed to and fro It must not be used as an elevator but tied with only sufficient raising of the lips of the incision or the laceration to assure proper coaptation without inversion Finally there must be absolutely no blanching of the tissues included within the suture when the latter has been tied The knot must be placed to one or the other side of the incision (Fig 65) The knot ends remaining after cutting never should be so long as to fall or turn into the incision The foregoing may sound like a repetition of homely and elemental things but it is prompted by the severe importance of the basic principles which enter into wound closure and are so often disregarded

Textbooks on surgery are replete with pictures and diagrams of wound closures showing beautiful geometric distribution of sutures both vertically and horizontally

This calculated positioning of sutures on both sides of the lips of a wound is sometimes possible and certainly makes for well appearing illustrations In actual practice and particularly in soft tissue reconstruction such geometric positioning is not to be insisted upon or even recommended Human tissue is not shoe hide It is a constantly and ever changing retracting and shifting material Therefore it is not subject to such rigid approximation except in the case of a relatively short and straight incision and only when its polarity is consistent with Langer s lines of tension

The distance at which sutures are inserted from the lips of an incision and from each other and also their direction across the incision are influenced in actual practice by several things First of all sutures should not be inserted too closely to the lip edge of a wound or placed too closely to each other Because no matter how lightly they may be tied the units of tissue left between the sutures may be too small in comparison with the thickness of the suture itself so that the reparative elements left unaffected by the trauma of the needle and the suture material are so few that healing

Fig 66 *Variations in incidence of suture angles to lines of incision* This is particularly necessary in the advancement rotation or shifting of tissues in order to splint adequately the lips of altered tissue relationships (see Fig 198)

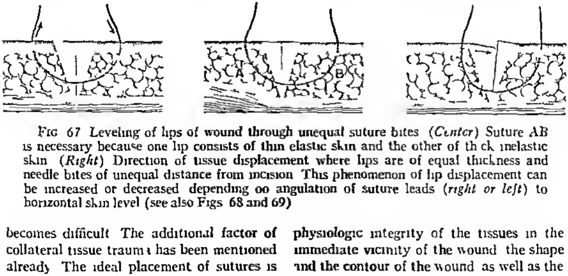


Fig 67 Leveling of lips of wound through unequal suture bites (*Center*) Suture AB is necessary because one lip consists of thin elastic skin and the other of thick inelastic skin (*Right*) Direction of tissue displacement where lips are of equal thickness and needle bites of unequal distance from incision This phenomenon of lip displacement can be increased or decreased depending on angulation of suture leads (*right or left*) to horizontal skin level (see also Figs 68 and 69)

becomes difficult The additional factor of collateral tissue trauma has been mentioned already The ideal placement of sutures is determined by the amount and the quality of tissues to be approximated the size of the needle and the suture material the physiologic integrity of the tissues in the immediate vicinity of the wound the shape and the contour of the wound as well as the conscience of the surgeon (Fig 66)

Incisions as well as lacerations particularly on the exposed parts of the body very

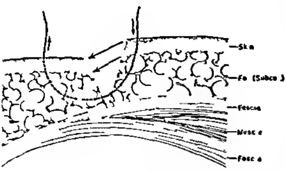


FIG 68 In this instance leveling is indicated because the lips are at different levels The wider needle bite of exiting suture lead lifts the lower lip while the smaller bite of entering or perforating suture lead depresses the right lip This can be augmented or reversed by varying the angles of perforation and/or exit (see also Fig 69)

often traverse or separate skin of different thicknesses and quality In general the more elastic or the thinner a skin the closer the sutures may be placed to the edge of the lip Conversely the thicker the skin or the more inelastic the farther away from the edge of the incision is it necessary to enter the needle Hence in the closure of an incision one lip of which consists of heavy thick and probably inelastic skin and the other of thin and elastic skin the distance of the needle puncture from the edge of the incision must be different on the two sides in order to get accurate leveling of the two lips (Fig 67) The same holds true for the distance between individual sutures In the thin or very elastic skin the sutures are usually placed closer together than in skin of opposite quality and merit Where the contour of a part or the subcutaneous dissection incident to the operation is such that it results in one lip of the incision s being lower as compared with the other an accurate and level appo ition of the skin edges cannot be produced until a wider bite is taken of the lower skin edge as compared with its mate (Fig 68) How much more of a bite should be taken of the lower lip is a thing which must be learned from experience as well as careful study of the quality of the tissue The wider the bite of a tissue usually the deeper it must be If in the above situation bites of equal distance are taken of the two lips the epidermis of the depressed lip will be opposed in its displaced position to the derma of its mate and a poor closure will result The lip of which less is taken will be pulled deeper into the wound than its mate of which more substance has been made available by a deeper and wider bite In general the wider and deeper the bite in the lip of the wound the greater is the tendency toward elevation of that lip The more vertical the bite the more pronounced is the eversion (Fig 69)

The same word of caution must be made against illustrations which regularly depict sutures always placed at exactly right angles to the incision In other words the suture is always shown forming a 90° angle to the polarity of the incision That sort of thing does not necessarily make for ideal repair The distribution and the integrity of elastic fibers in the two lips of an incision or a laceration are not always identical and therefore a certain amount of ungeometric displacement of tissues or shearing is present as long as the wound remains open To replace such segments properly one is forced to place sutures at other than 90° angles to the line of incision In the act of tying such sutures are then said to advance one lip upon the other

The angle at which the suture crosses the line of incision should be a matter only pertinent to the proper anatomic appo ition of the parts Adequate anatomic apposition dictates constant variation of the angle of placement of sutures with reference to the polarity of the wound

The reasons cited above as necessary for variations from suture to suture are also the reasons why the interrupted suture as contrasted with the continuous is the more nearly ideal method of closure The very fine points in the technic of suturing can be

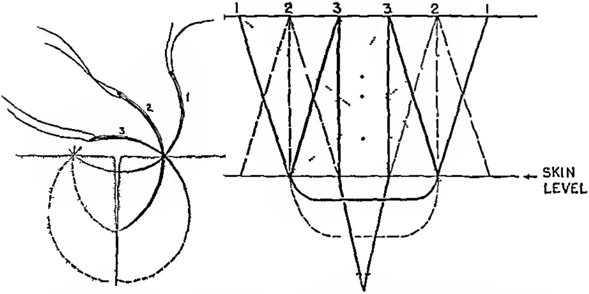


FIG 69 Diagram of suture angulation Needle angulations in left hand drawing result in corresponding lines of tissue forces (1 2 and 3) as shown at right The degree of tissue lift above skin level (level of apposed lips) then becomes the summation of two forces—the distance of needle from incision and the angulation of needle through skin

applied only with absolute accuracy to individual or interrupted sutures This is not to say that it is impossible to apply these things to continuous forms of suturing but only that in the latter case it is more difficult and not as dependable as in the interrupted form Wherefore the latter is the suture of choice in *corrective surgery* though it is time consuming Time always must be of secondary consideration in reconstructive or creative work

EVERSION INVERSION AND OVERCORRECTION

The occasion for deliberate eversion inversion or overcorrection only occasionally arises in general surgery where closure of a wound is usually a matter of simple adaptation more or less secondary to the over all object of the operation In plastic surgery it is a common problem and routine concern It is necessary in order to circumvent the consequences of trauma (*viz* fibrosis retraction and atrophy) and their relation to re establishment of original symmetry and appearance

EVERSION

Deliberate eversion of tissues is necessary in reconstructive surgery because inversion is the unavoidable consequence of the disruption of the subcutaneous fat and the fibrosis which follows incision or laceration The disruption of the fascial integrity after injury leaves an anatomic vacuum under the overlying skin whether the latter is actually broken or not Hence come the depressions which follow even closed trauma due to contusion The amount of fibrosis which occurs in subcutaneous tissue during the period of healing results in the loss of a degree of cushioning to the overlying skin The loss of resiliency of the incised skin and the contraction consequent upon its replacement by scar leads to the pulling inward of the line of incision in the direction of the fibrosing subcutaneous fat To compensate for the above eversion during closure of a wound becomes a formative necessity

Eversion can be accomplished in one of three ways by overlapping of the remain

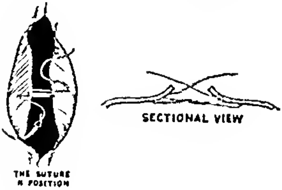


Fig. 70. Far-near suture technic (after Gillies)

ing subcutaneous tissue by some form of suturing which will tend to turn the lips of the wound outward or by a combination of the two. To accomplish the first the edges of the wound are undermined somewhat at the level between the skin and the subcutaneous tissue so that the latter forms a distinct and separate layer whose lips can then be superimposed one upon the other and sutured in that position by plain catgut. The skin edges are then everted either by some form of subcutaneous suturing as the "far-near" technic of Gillies (Fig. 70) or by inserting interrupted sutures into the underside of the dermis at some distance from the edges of the wound. In the latter case it is usually necessary to insert a few fine interrupted sutures into the epidermis in order to accomplish airtight closure of the wound. The two steps may be combined in one by inserting the sutures transcutaneously deep into the underlying fat and at an angle greater than 90° (Fig. 69). When the sutures are tied they gather more than the usual amount of subcutaneous tissue under the line of incision, thus bellying the incision outward. When this type of closure is used no additional sutures are necessary in the epidermis because the transcutaneous suture tied over the incision will oppose it without difficulty.

Eversion can also be accomplished by using the horizontal mattress suture, the mechanics of which are designed to accomplish the eversion by vertical crowding of the dermis toward the center of the wound so that more than the required amount is pressed into service under the epidermis. This crowding leads to eversion. When the horizontal mattress suture is used it must never be tied too tightly. If one must err it is better to do so on the side of tying the suture too loosely. Should it be tied too tightly it will result in interference with circulation of the tissues embraced by the suture (Fig. 71).

Inversion

Inversion, since it is the natural concomitant of the process of healing, is frequently sufficient in itself to re-establish original or normal details of contour. On the other hand it is occasionally necessary to augment it in regions where normally a crease or narrow depression exists in the skin. When in the course of operation this normal creasing has to be interfered with by excisions because of the presence of scar tissue, the crease must be re-established for purposes of appearance.

To accomplish this type of inversion at times it is sufficient merely to close the wound without effort of eversion. If the creasing of a part is normally very pronounced, as in the case of the melonasal crease, it is necessary to excise a beveled strip of skin and a wedge of subcutaneous tissue under the skin so that a definite de-

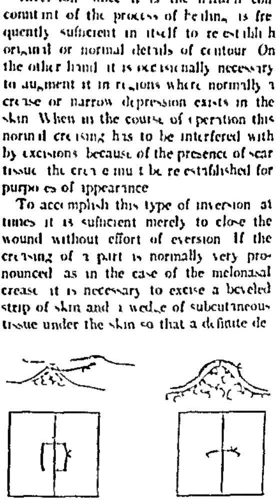


Fig. 71. Horizontal and vertical mattress sutures. Note the greater acuteness of skin eversion in the case of the horizontal mattress.

pression results following closure (Fig. 72). To assure sufficient esthetic inversion, the needle should be passed through the entire thickness of the skin at an angle of less than 90 degrees. This, of course, results in the inclusion of a wider epidermic surface in the confines of the suture as compared with the amount of the derma, so that when the suture is tied the quantity of the epidermis gathered toward the center tends to depress the dermis into the wound.

In order to guarantee this type of inversion resulting in a crease, the wound must be splinted for a period of at least 3 weeks postoperatively in some manner. The simplest one is to paint the postoperative scar for about a half inch to either side of it, with collodion. When the latter contracts in the process of drying, it has the tendency to continue to pull the epidermis toward the center and in that fashion maintain the depression.

Overcorrection

Overcorrection of a repaired part is an unavoidable necessity in reconstructive surgery, more common than its counterpart. It must be practiced in all relatively extensive repairs and must cover all *three dimensions* in all directions of the repair. In other words, if the normal contour of the part *prior to injury or incision was convex, the* repair must be so planned that the convexity is obviously exaggerated. This is particularly true in tissues which normally contain considerable subcutaneous fatty tissue, such as the cheek. Fatty tissue, being pre-eminently vulnerable to all forms of trauma, has a greater tendency toward postoperative liquification, absorption and substitution by fibrous tissue which results in considerable retraction and therefore, in the case of the cheek, in obvious flattening. Where the original injury has already resulted in the loss of considerable subcutaneous tissue, it is necessary to utilize other tissue in the vicinity of the wound if possible and to bring them into the depths of

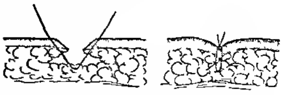


Fig. 72. Inversion technic (Pick's) to mimic normal skin crease. Note triangular or wedge-shaped excision of subcutaneous fat. Also the angle of incidence of suture leads.

the repair in order to make it possible to overbuild the closure (Fig. 73).

It is not likely that this type of convex overcorrection can be exaggerated. It is far better to err on the side of overcorrection. The process of organization of the postoperative closure plus the attendant fibrosis for many weeks or even months to come will continue to retract the overcorrected part to an amazing degree. If, in addition, considerable surgical trauma has been committed in the wound, a certain amount of postoperative atrophy of the mobilized tissue will result, adding to the reduction of the size of the overcorrection.

Only when the normal contour of the surface is concave must one be careful not to *bring too much* tissue into the wound during its repair. Overcorrection in the concave direction is not as difficult as the re-establishment of *convexity. If the concavity* should be inadequate it always can be augmented by simple excision of additional tissue.

Overcorrection in the direction of concavity tends to be neutralized only slightly as healing progresses, but overcorrection in the direction of convexity may be neutralized from 50 per cent to 60 per cent or more with the lapse of time. In any case this depends largely upon the type of tissue that has been used in the correction, the manner in which the overcorrection was executed and the quality and the duration of postoperative splinting.

The greatest enemy of any type of correction is postoperative fibrosis. The sur-

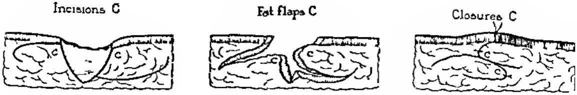


FIG 73 Overcorrection of skin surface by superimposition of pedicled subcutaneous fat (Gillies)

geon has no way in which to gauge the exact amount which will take place or its influence upon the repair By kind treatment of all tissues in the course of the operation he can modify only to a degree the amount of fibrous tissue which will be generated in the wound Likewise to a certain degree he can modify the distorting effect of the fibrous tissue upon the repair by adequate splinting over the required period of time

Fibrous tissue changes the contour of a part through contraction As a result a certain degree of distortion or at least loss of symmetry of a part always results if healing is attended by too much fibrous tissue Unless this is taken into consideration what otherwise appeared to be an acceptable immediate repair will in due course of time become disappointing

The application of the foregoing principles in the repair of accidental wounds is discussed in Chapter 15 Original Repair

BIBLIOGRAPHY

Berens C and Romaine H H A comparative study of sutures employed in surgery of the extra ocular muscles Tr Am Ophth Soc 81st Ann Meet Hot Springs Va 1945

Bower J O and Pearce A E The superiority of fine catgut over fine silk as a mucosal suture in gastric surgery Surg Gynec & Obst 74 649 1942

Burch E P The corneo scleral suture in military ophthalmology Mil Surgeon 93 286 1943

Burian F Fysiologicke Operovani Knihtis karna Tispus V Praze 1945

Coventry M B and Beck N R Primary tendon suture J A M A 135 No 2 1947

Cutler E C and Dunphy J E The use of silk in infected wounds New England J Med 224 101 1941

Daley J Role of columellar and septocolumellar sutures in rhinoplasty Arch Otolaryng 45 1"8 1947

Derbyshire R C Complications following the use of cotton as suture material Surg Gynec & Obst 84 No 1 1947

D Ingianni V Cotton as a suture material South M J 38 No 12 1945

Evans J G Sano tissue glue skin grafting J Internat Coll Surgeons 8 No 5 1945

Fast J Nelson C and Dennis C Rate of gain in strength in sutured abdominal wall wounds Surg Gynec & Obst 84 No 4A 1947

Gaston E A Living fascial sutures in inguinal herniorrhaphy Arch Surg 54 441 1947

Gilbert J T Use of a continuous non absorbable buried suture throughout in operative procedure Am J Surg 77 93 1949

Gillies H D Plastic Surgery of the Face Oxford Med Pub 1920

Guilbert H D Suturing infected wounds of the face J Internat Coll Surgeons 7 No 1 1944

Halsted W S Bull Johns Hopkins Hosp Dec 1889 p 13 Bull Johns Hopkins Hosp March 1893 p 21 J A M A April 12 1913 p 1119

Hersh J A modified circumcision suture technique Am J Surg Jan 1939

Holman C W Eckel J H Jones T E Newell E T Jr and Brubaker R E Use of silver wire and alloy steel sutures Prevent wound disruption following abdominal closure Surg Gynec & Obst 72 1052

Howes E L A renaissance of suture technique needed Am J Surg (N S) 43 548 1940

Koontz A R and Shackelford R T Tissue reaction to ribbon catgut and preserved ox fascia lata strips Am Surg 115 No 6 1942

Lesser A J New tension suture technic Am J Surg 74 No 4 1947

Magrath J L Suture dressing anchor Am J Surg (N S) 58 No 3 1942

Meade W H and Ochsner A The relative value of catgut silk linen and cotton as suture materials surgery 7 485 1940

Preston D J The effects of sutures on the strength of healing wounds Am J Surg (N S) 49 No 1 1940

Scholz R P and Mountjoy P S Fiberglas suture material preliminary report Am J Surg (N S) 56 No 3 619 1942

Searcy, H B, Carmichael, E B, and Wheelock, M C Implant material The production of fibrous tissue around the fibers of cotton and other foreign material implanted subcutaneously in rats South M J 37 149 1944

Shelden C H, Pudenz R H, and MacCarty, C S Tantalum scalp sutures Surgery 21 106 1947

Stevens G A Sloan H P Wickham W A and Foltz, T P Fine chronic catgut versus cotton sutures in wound closure, J Internat. Coll Surgeons 9 No 6 1946

Sulzberger, M B, Baer, R L Lowenberg C, and Menzel H. The effects of fiberglas on animal and human skin—experimental investigation Indust Med Oct 1942

Tauber R Twin stitches Journal of the International College of Surgeons 11 200, 1948

Thorek, P Five years' experience with spool cotton as a suture material Routine use in over 1 000 operations, Am J Surg 71 652, 1946

Tidrick, R T Fibrin fixation of skin transplants Surgery 15 No 1, 1944

Wiley, H M, and Sugarbaker E D An evaluation of abdominal wound closure steel wire layer closure compared with catgut silk layer closure Early and late results, Surg Gynec & Obst 85 No 1 1947

Wolbarst A L Ribbon Gut in Surgery J Internat Coll Surgeons 7 No 3 1944

Young F, and Favata, B V 'Suture" of wounds by plasma thrombin adhesive War Med 6 80, 1944

candy or take a few drops of grapefruit juice every hour or two for the first 48 to 100 hours

Where the danger of parotitis seems to be in the offing, it may be necessary to give pilocarpine hydrochloride in strengths of 1/20 gr (3 mg) every 4 to 6 hours in adults This should be complemented by external heat Where this does not seem to be sufficient, X ray treatment may be used To be telling in its effect, the latter must be used early, before the lapes of 72 hours, if possible Other measures such as the probing or drainage of the ducts is not a procedure to be generally or routinely encouraged It is not a comfortable thing after intra oral surgery, and there is always the danger of injuring the orifice of the duct External drainage, though often resorted to, is not recommended It very frequently results in the introduction of secondary infection, which makes an already difficult situation only more complicated With the advent of penicillin and streptomycin this complication has lost some of its horrors Nevertheless it is not wise to expose a patient to injudicious surgical meddling because one can fall back on a therapeutic broom to sweep up the mess Even without secondary infection the surgical drainage of the parotid gland is a relatively traumatic affair which may leave in its wake considerable esthetic distortion

In children where some of the commoner measures of oral hygiene, such as spraying or washing are difficult, swabbing will be sufficient if it is done very thoroughly

DRESSINGS

Dressings in plastic surgery have a place only second in importance to the operation itself The basic reason for this is that whereas in general surgery the incision is only the most direct and simple approach for the purpose of tissue excision, in plastic surgery it is an integral and complex part of an exact anatomic reconstruction for the purpose of functional esthetic correction The former terminates in a simple surgical wound usually closed by ordinary approximation and only needing physical protection against postoperative contamination In the case of the plastic surgeon, most situations call for a dressing which is a coverage subserving many functions

Types of Dressings

There are two main categories of dressings One is the inorganic or conventional type and the other is the biologic type represented by the epidermic graft Frequently as in third degree burns, both are necessary The adequacy of a dressing in reconstructive surgery is determined by its nature or composition Its composition must always subserve its function

Purpose of a Dressing

The purpose of any dressing in plastic surgery is fivefold hygienic, mechanical, therapeutic functional and sometimes curative

The hygienic purpose, though important as in all forms of surgery, is ultimately the relatively least of its five purposes Nevertheless, one must maintain sterility and avoid postoperative contamination by adequate coverage

The mechanical purpose is even more important than it is in other types of surgery, except possibly in orthopedics and ophthalmology The essential mechanical function is that of splinting This is necessary in order to avoid the pull and the distortion of gravity, and collateral tissues, upon the repair Lastly, the tendency peculiar to almost all cut tissues is one of self displacement or shrinkage The adequate splinting of soft tissues is not only important but frequently more difficult than the splinting of bone or joints The difficulty becomes particularly evident in the splinting of reconstructions about the nose, mouth, chest or genitalia where certain fundamental functions such as respiration deglutition, chewing and excretion must

FIG 74A Plastic dressings (*Left*) Method of applying pressure dressing to both ears without bandaging head One piece of adhesive is run completely around the head once All other strips necessary originate with this strip in the frontal region and terminate on same strip at the back of the neck

(*Right*) Full face pressure dressing It is the most difficult to do since adequate allowance must be made for basic functions of respiration mastication and vision These dressings are indispensable in extensive burns involving the head and the face

continue at one and the same time that the reconstructed part is going through the healing process Often this task takes considerable imagination as well as effort and leads to some very ingenious forms of coverage (Fig 74)

Another important mechanical function of the dressing is the preservation of the form of the repair until organization is complete The maintenance of form in plastic surgery as indicated in Chapter 23, Esthetic Surgery is one of the most important aspects of the repair not only for the purpose of guaranteeing symmetry of the part but adequate function as well

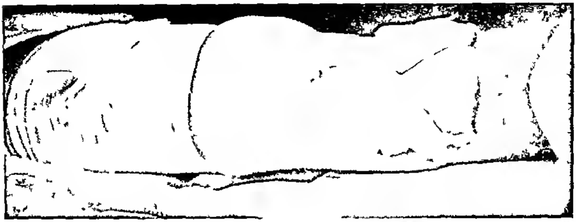
The therapeutic purpose of a dressing means two things noninterference with wound healing and expediting of functional rehabilitation The dressing must be occlusive enough to maintain the temperature of the part as well as its humidity and still not interfere with drainage or whatever incidental treatment is necessary to the repair, such as irrigation or application of chemotherapy (see Plate 3)

A dressing never must be allowed to stick to a wound When this occurs it acts as a foreign body and an irritant Consequently, that part of the dressing immediately adjacent to the wound usually consists of some type of oil impregnated gauze such as petrolatum jelly scarlet red or boric ointment Petrolatum jelly is a questionable substance to incorporate in any but the dressings which cover completely closed wounds This is particularly true of dressings applied on third degree burns Neal Owens and his associates, after rather extensive research, have come to the conclusion that rayon is the most ideal surgical dressing for surface wounds Owens states

> Investigation and clinical use, for a period of two years, has shown that rayon is an ideal

PLATE 3

Excellent results following an adequate burn dressing Note the extensive amount of "spontaneous" epithelialization in an obviously third degree burn of both lower extremities Much time, tissue cost, nursing and hospitalization was saved and need for grafting reduced to a minimum The proximal coverage of wound consisted of plain fibreglas gauze This was superimposed by plain gauze pressure dressings The burn case was received "fresh" The case (at the time of the first posttherapeutic dressing) is 19 days old



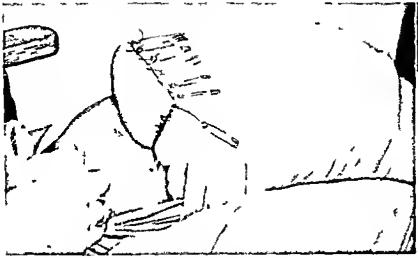


Fig 74B Plastic dressings (*Continued*) (*Top*) Application of bundle dressing to leg A sufficient number of long sutures are inserted outside the area of defect, then tied over the dressing Bandage is then applied over bundle This is particularly advantageous in areas otherwise difficult or risky to bandage (chest after general anesthesia) and in young children

(*Bottom, left*) Pressure dressing over underlying free grafted donor site of pillowed pedicle Latter is splinted to outside of pressure dressing by safety pins attached to running epidermal suture in the edge of 'pillow ' The pillowed pedicle is dressed separately, to pressure dressing Later when pressure dressing is removed, epidermal suture in pillowed pedicle is also removed and substituted by collodion strip Latter acts as point of anchorage for rubber bands via safety pins The rubber bands are attached to adhesive strip below knee to maintain constant minimal traction on "pillow," avoiding shrinkage (cf Fig 9) (*Bottom, right*) Sterile washed x ray film as protective dressing on hypersensitive skin or painful lesion Permits daily observation Bisect corners to mold film

material for dressings in immediate contact with any surface wound It fulfills the physiologic requirements for an ideal material to be placed in immediate contact with a surface wound, permits adequate drainage, reduces friction with the wound to a minimum, prevents capillary invasion as result of fineness of the weave, and reflects a great reduction of pain and bleeding when dressings are changed It is easily sterilized and withstands

stop the bleeding For some reason if the surgeon does not actually see the blood he does not seem to realize that bleeding may go on subcutaneously *

As far back as *1924* Blair laid specific emphasis upon the element of pressure in dressings as follows

The application of most any dressing produces pressure but he who employs this pressure in a *selective purposeful manner will get* bigger returns than he who applies it incidently or even as a matter of routine †

Neal Owens states that

It has been our experience that by the use of pressure dressings in the treatment of burns and infected wounds the incidence of complications due to infection has been lowered the duration of hospitalization shortened and the complications reduced A properly applied pressure dressing offers comfort to the patient *during* the *first 18 to 21 days because of* evenly distributed pressure and its splinting effect This is in favorable contrast to those patients in that group who presented initially only contaminated wounds who formerly were subjected to the terrific pain associated with frequent change of dressings during this period The method of applying a pressure dressing is described in detail ‡

A plastic dressing must serve the latent *integrity of* the *repair until it becomes* manifest through organization To fail in this respect is to sacrifice function of the part To gain the most function through reconstruction the dressing must be a physical part of the repair and yet not interfere with the physiologic welfare of the part For instance a wound of the chest must be adequately dressed from the standpoint of the repair and yet not interfere in any way with respiration The same holds true for *reconstructions* of the *mouth* nose eyelids anus hands and the genital organs

* Treatment of patients with severe burns Surg Gynec & Obst 74 914 1942

† The influence of mechanical pressure on wound healing Illinois Med J 46 249 1924

‡ Owens Neal Use of *pressure dressings in the* treatment of burns and other wounds Surg Clin of North America 1943

Fig 76 Application of bundle dressing over full thickness graft covering lower eyelid and left side of nose Indentures at top and bottom of dressing denote placing of sutures tied over dressing to maintain its position In the case of the face if bundle dressing covers graft widely bandaging may be avoided Patient can shave

One of the simplest ways in which to make the dressing part and parcel of the repair is to tie the two in a bundle as it *were This is accomplished by placing* relatively stout sutures at calculated distances from the wound so that these may be tied over the dressing (Fig 76) This bundling of the dressing makes it a physical part of the repair No matter in which direction the excursions of that part are projected *the dressing travels with the repair* and the region The sutures tied over the dressing usually accomplish their task by the fourth or the fifth day and can then be removed without leaving any evidence of their presence The placing of adhesive strips over a dressing for the above purpose although commonly employed is not recommended because the adhesive always interferes with the normal excursions of the region and its

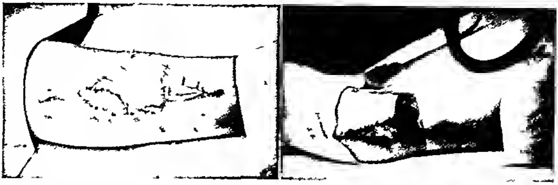


Fig 77A Epidermic (biologic) dressing (*Left*) Large sheet of epidermis splinted into position with an occasional basting suture to cover loss of epidermis over tibia, as shown at right The epidermis is then covered by a conventional pressure dressing (Fig 75) This is a rapid method of making a closed wound out of an open wound or of ablating superficial raw areas

sticking to parts in constant motion is very unreliable

The curative purpose of a dressing is to be found in the so called biologic dress ings pre eminently represented by the epi dermic or thin split grafts (Fig 77) The graft forms the proximal layer of the dress ing in lieu of such traditional things as petrolatum gauze Such coverage is now used in the treatment of superficial ulcers saucerized bone cavities and various exten sive granulating surfaces The curative function is basically true insofar as the ap plication of epidermis in such instances creates a closed wound out of an open wound

The use of the epidermic grafts is the most recent addition to the problem of adequate surgical dressings It is the direct result of the popularity and the ease of mobilization of these grafts Whereas the epidermic and thin split grafts are fre quently used as a means of correction of superficial defects actually the graft is nothing more than a permanent biologic dressing Its use for functional replacement of tissue loss is very limited due to the fact that it tends to pigment out of proportion to the surrounding skin shrink to a point frequently inconsistent with adequate func tion and almost universally results in the deposition of scar tissue under the graft which makes such repair only partially satisfactory

From the standpoint of healing, the epidermis or the thin split graft make the most formidable and satisfactory types of coverage Under ordinary circumstances, they need to be applied only once without any necessity for changing them subsequently The thin graft can be placed on relatively unsterile fields with considerable degree of success When used as biologic dressings, these grafts do not necessarily need to be sutured in position, but simply laid on the wound or wrapped about the part and secured by appropriate pressure Their ap plication and management is no different fundamentally from that of any other type of skin graft Their more extended use will be discussed in Chapter 15, 'Original Repair'

Other types of curative biologic dressings are such as involve the use of dried red blood corpuscles tissue extracts and homografts Because of their relatively experimental status these various forms of dress ings will be discussed elsewhere

The question of dressings has by no means been reconciled On the contrary, the subject deserves much more thought and further investigation Considerable progress has been accomplished in the past decade, but much more remains to be done

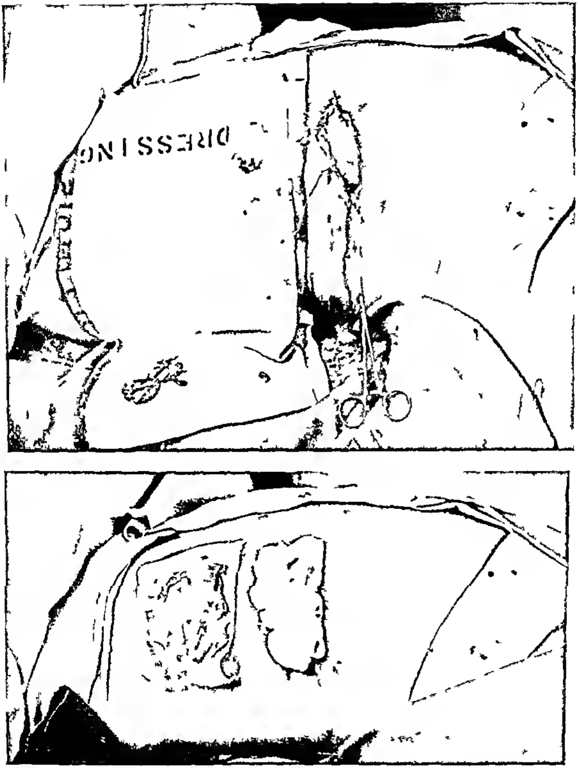


FIG 77B Epidermic (biologic) dressing (*Continued*) (*Top*) Immediate epidermic dressing of debrided chest wound not involving pleural cavity (*Bottom*) Same case as above illustrating bundle coverage of epidermic wound dressing and (to left) fiber glas coverage of donor site Note high degree of capillarity and immediate drainage of serum through double layer (For further uses of fiberglas gauze as proximal dressing see Chap 16)

THE PATIENT

The necessity for meticulous postoperative care of the patient as a whole cannot be overemphasized It is fully as important as the operative procedure itself Its purpose is twofold to preserve and guarantee the surgical repair and to insure the comfort of the patient The ultimate results in reconstructive surgery are often in direct proportion to the quality of such care It should begin the moment the patient is removed from the operating table and placed upon a cart to be delivered to his room

The patient should be well covered to avoid exposure and specific attention should be paid to the reconstructed part This is especially true of a patient who has been operated upon under general anesthesia

The specific attention to the reconstructed part concerns itself essentially with protection of the dressing and the splint A patient who has been subjected to a general anesthetic should be so placed as not to rest on the dressing and to avoid soiling of the dressing in event of vomiting From what has been said in connection with the functions of a dressing in plastic surgery it must be obvious that its integrity must be preserved under any conditions Any interference with it is equivalent to the dislocation or the fracturing of a plaster cast in an orthopedic case The patient and his *dressing should be protected until he has* regained consciousness even though this may mean the constant presence of some one at his side Where surgery has been done upon the mouth the cheek or intraorally and where postoperative salivation oozing or vomiting may occur a suction machine must be sent along with the patient

Upon regaining consciousness the patient should be advised about his dressing or the splint and warned against disturbing it or disarranging it in any way If the dressing has been properly planned and satisfactorily applied in the operating room it will cause no discomfort to the patient whatsoever If for any reason it has been disturbed while the patient was en route to his room it must be revised immediately It is a profitable habit never to leave the hospital after a morning of surgery until one has rechecked the dressings of all patients operated upon that day This is particularly important where a dressing may interfere with a patient s ability to swallow breathe or void Nothing is gained by neglecting the first opportunity to correct such a condition which causes annoyance and discomfort to the patient and possible embarrassment to the surgeon

The necessity for correcting a dressing immediately after operating should be considered as an emergency From a physiologic standpoint it is far more risky or even dangerous to redo a dressing 6 hours or more after operation than to correct it within an hour or two because after about the sixth postoperative hour the tissues in the field of reconstruction begin to swell there is venous engorgement exudation of lymph into the wound lymph stasis within the interstices of the tissues a dressing changed at such a time is impossible of original adjustment

POSTOPERATIVE COMPLICATIONS

Dressing Complications

Inspection of the dressing should be done by the surgeon himself at certain specified periods or intervals It should be inspected immediately after operation for its appearance, physical adequacy bleeding into the dressing and for the patient s comfort It should be reinspected approximately 6 to 8 hours later for possible physiologic implications By that time an originally comfortable and adequate dressing may have become too tight or even displaced due to postoperative edema hemorrhage hematoma or seroma In such instances an originally good dressing may become a danger

ous one Due to swelling of the part or hemorrhage under the dressing, the latter may exert too much pressure against the repair and so interfere with circulation A vicious circle is thus established

The dressing should again be inspected very carefully about 18 hours postoperatively for its anatomic adequacy By that time bundle sutures, adhesive strips collodion strips or whatever means were employed for securing the dressing may have become loosened, untied stretched or in some way may have disappeared, thus permitting it to be dislodged or so twisted that it has lost one or another of its purposes

After the lapse of from 24 to 36 hours the dressing should be inspected again for possible signs of wound complications If an infection, hematoma or partial disruption of the wound has occurred it can be very definitely detected by that time If the postoperative edema is still increasing it will have led to some venous stasis, even arterial occlusion, or displacement of the lips of the wound In the case of pedicle flaps or tube pedicles dangerous interference with the circulation and resultant gangrene becomes a matter of great concern If observed at this time there may still be ample opportunity to remedy the situation

Since many patients undergoing plastic reconstruction are not actually ill and are able to leave bed after from 24 to 48 hours it is doubly necessary that the dressings be inspected for their cleanliness and appearance It is no recommendation to anyone concerned in the case to have such a patient walking about the halls of a hospital with an unclean unsightly or bedraggled looking coverage

Since most patients operated upon under general anesthesia have some form of preoperative sedation which may continue for many hours postoperatively the 24 hour inspection period of a dressing becomes doubly important Such patients while under sedation, frequently are unable to complain of any discomfort which the dressing may occasion If any faults or inadequacies exist in the latter, it may be too late to remedy them after the 24 hour period It is not good policy to relegate this responsibility to untrained assistants For the same reason the surgeon must be very circumspect about all postoperative sedation particularly in the first 48 hours A patient oversedated is in no position to complain of the consequences of an inadequate splint

After from 48 to 56 hours in cases where no free grafting has been done the dressing may be removed with safety for direct inspection of the wound itself The re dressing of the wound must be consistent with surgical asepsis and the conditions of the operative wound at that time If any sutures are found to be too tight if there is any seepage if the skin edges have been dislocated for some reason if blisters have appeared or if there is venous stasis immediate correction of these things is indicated None of these must be overlooked or disregarded for at the time of the first change of dressing the best opportunity comes to hand to correct all minor wound complications

Wound Complications

If a patient complains of discomfort under the dressing soon after returning from the operating room it is due to the unavoidable surgical trauma rather than to the dressing or any complication within the repair But should he begin to complain of pain after the lapse of from 6 or 8 hours, when postoperative edema becomes a factor in the relationship between the dressing and the wound then it is fair to assume that a dressing which originally may have been comfortable has now become too tight Some slight correction or alteration may be necessary

Where pain and discomfort come on from

18 to 24 hours after operation it is probable that there is trouble in the operative wound itself This may be due to infection serous effusion into the wound hematoma displacement of the wound edges or tight sutures Where pain or discomfort appears on the third or the fourth day or thereafter there probably is serious trouble in the wound This may be due to the pulling of sutures secondary hemorrhage low grade infection necrosis of tissues for one or another reason or gangrene These may take place in spite of the fact that the dressing has been fully adequate all this time The foregoing analysis of the clinical picture applies to wounds where no grafts have been used

Where free skin grafts have been employed it has been my experience that there exists a rather dependable clinical pattern a sort of reversible triad which renders quick information as to the condition of the wound without having to remove an otherwise adequate dressing The triad is pain odor temperature or its reverse temperature odor pain The order of development of the two sets of symptoms is determined by the primary cause of trouble in the graft or the wound The **P O T** as contrasted with the **T O P** means that the graft is suffering with primary necrosis due to inadequate circulation leading to pain then odor from decomposition of necrotic material and finally temperature due to absorption and/or secondary infection whereas in the T O P triad the graft is suffering primarily due to an infection which has set up the clinical picture by an initial rise in temperature (local and later general) instead of beginning with pain When a patient s first complaint is pain on say from the third to the fifth day in the grafted area and particularly when he is inclined to point with a finger to a painful spot under the dressing there probably is trouble with the graft due to necrosis resulting from disturbed or originally poor apposition and consequent inadequate circulation If on the other hand the patient has been developing a slowly rising temperature and adds that there is thumping under the dressing usually after the second or the third day and this is succeeded by pain the destruction of the graft is due to infection The pain in the infected case is of a gradual onset intermittent thumping in character and relatively more severe whereas the pain of necrosis is of more rapid development rather continuous in character and at first a kind of ache finally resulting in actual pain which may be quite tolerable and therefore must be inquired for in some patients Unless one of these triads is present one never should worry about the graft or allow curiosity to precipitate adversity by peeking under the dressing which is one of the greatest temptations and most formidable dangers with the nov ce or the occasional operator in plastic surgery It is a bad habit based upon fear due to inexperience and leads to disaster through loss of pressure or an infection

THE HYGIENE OF RE DRESSING

Wound hygiene during change of dressing must be observed with the same care as the preoperative preparation of the field

The entire wound whether it be incisional accidental or a grafted one should be thoroughly cleaned with saline or half strength hydrogen peroxide until every individual suture can be identified This may take time Nonetheless the time spent in this sort of thing is very worth while The thorough and meticulous cleaning of a wound prior to re dressing permits minute inspection of every suture and unit of tissue Any crusts present must be gently and carefully removed If this is not possible without prolonged soaking with saline or half strength hydrogen peroxide the time must be found Crusts or accumulations of debris about the wound or the ends of sutures never should be removed by force

This is an inexcusable injury to the epidermis and almost invariably results in a poor scar Nevertheless they must be removed because if allowed to remain they sooner or later dry and act as irritating foreign bodies The skin reaction to crusts is the result of the pressure of the latter on the young epidermis or the result of chemical changes going on under the crusts which sooner or later lead to ulceration This is followed by necrosis and even disruption of the wound

Due to minute histologic changes in the repair resulting from the surgical trauma the tissues of the incision and even the collateral tissues for a certain distance from the incision for a minimal period of 5 to 6 weeks suffer with residual neurocirculatory disturbance which makes such tissue far more subject to irritation than it normally would be Therefore it is entitled to greater than ordinary care and protection

Hygiene in plastic surgery is a kind of ritual It is time consuming but in the end it pays great dividends For this purpose in general there is no better medium than soap and water Prior to the complete organization of the repair brush scrubbing is not permissible Fluffed dressings or cotton are best for this purpose This avoids injury *to the repair and accomplishes the desired results*

Having removed all the debris and crusts from such a repair the interstices between the sutures should be carefully inspected for the presence of small blisters clots suture ends hair and any other type of foreign body which may have found its way to the incision These must be removed with utmost caution sometimes under a magnifying glass so that no injury is inflicted upon the epithelium

The entire surgical field should then be cleansed with alcohol and dry sponged immediately A few minutes should be allowed to elapse for the tissues to dry completely The surgical repair or the borders of the grafts as the case may be may be lightly painted with compound tincture of benzoin This is allowed to dry completely before any dressings are applied Finally a layer of xeroform gauze is laid on the wound and this is superimposed with dry dressings which should be securely bandaged into place

Where a free graft has been used in the reconstruction of a defect the most important purpose of the overlying dressing lies in its splinting value It never must be changed in less than 100 hours except under unusual circumstances The length of time of noninterference with a dressing in such cases depends upon the type of graft employed When an epidermic graft is used a dressing may be removed after 100 hours without serious injury When a thin split graft is used 150 hours on an average should elapse before the dressings are removed When a thick split graft is used up to 200 hours should be allowed to elapse before the dressing is changed Where a full thickness skin graft has been employed 250 hours must be allowed to elapse before redressing the case

To put it another way approximately 10 hours must be allowed for every 0 001 in of thickness before any first inspection of a *graft is permissible This time element may be decreased as the graft exceeds 0 016 in* and increased if the quality of the bed or the general condition of the patient is below average

The new dressing is one whose primary object is the protection of the graft against injury movement dislodgment or infection These precautions must continue until organization of the 'take has resulted in complete physiologic communion between graft and recipient site with the exception of innervation The time element involved depends to a great extent upon the type of skin graft employed It varies from about 19 to 60 days The thicker the graft the more time should be allowed to elapse be

fore it is exposed without a dressing A minimum of 2 5 ambulatory days is allowed for each 0 001 in of graft thickness before it is safe to expose it to ordinary wear and tear This is especially important where exposed parts of the body or the genitals are involved

FEEDING

Patients must be fed postoperatively The manner of feeding and kind of food should be planned before the operation Aside from a patient s discomfort and unhappiness from improperly applied dressings no omission is so unjustifiable as failure to plan or to provide for the proper feeding of the patient This is particularly true after operations on or about the mouth Postoperative feeding in extensive operations about the orifices is as important as a planned dressing of a patient after genito urinary surgery What is put into the patient and how it is done may have much to do with the result of the operation its manner of elimination will have much to do with his comfort and sometimes with the surgeon s reputation

The majority of patients operated upon for tissue reconstruction are able to eat by themselves Where a general diet is not advisible soft or liquid diets will answer the problem Where even the latter cannot be taken normally some provision should be made preoperatively or during the operation such as the insertion of a transnasal tube so that the patient can be fed In cases where there is any question preoperatively about the manner of feeding it is far better to insert the tube during or immediately after the operation than to wait until the patient is conscious It is far easier to remove the tube found to be superfluous than to try to insert one particularly in a child or an adult who is not very co operative

Where only a liquid diet is permissible as it frequently must be following intra oral surgery or extensive operation on the face from 2 000 to 2 500 calories a day usually proves to be sufficient for at least the first few days in the majority of cases Liquid diets are often attended to somewhat haphazardly As a matter of fact it is in these cases that a properly balanced diet is most important

Brown Byars and McDowell give the opinion that there is apt to be too much carbohydrate in the liquid diet They recommend and outline a diet* (see below) which they have used successfully for years and feel that it is a fairly good balance

* Brown James Barrett Byars Louis T McDowell Frank Preoperative and postoperative care in reconstructive surgery Arch Surg 40 1192 1210 1940

	Gm	Calories
Protein	75	300
Fat	100	900
Carbohydrates	350	1 400
		2 600

	Ounces	Cc	Protein Gm	Fat Gm	Carbohydrate Gm	Calories
Six Eggs	6	180	36	30		450
Cream (20 per cent)	8	240	8	48	8	480
Milk	24	720	24	24	48	480
Tomatoes (strained canned)	6	180	3		6	36
Dextrose Karo Dextrin or Lactose	10	300			300	1 200
Salt	1 tsp					
	54	1 620	71	102	362	2 646

The feeding of any type of patient involved with plastic surgery, is a very important phase of preoperative, operative and postoperative management, because in the first instance it exerts influence upon the integrity of the tissues to be reconstructed, in the second case it has considerable to do with the patient's comfort and resistance, the quality and the rapidity of the healing process, and in the last instance with the length and the quality of his convalescence A patient who enjoys his food seldom complains of his hospital stay A well fed patient is usually a happy one (For vitamin requirements see Chapter 11)

Tui and Levenson have estimated that as much as 300 Gm of protein may be necessary per day in order to supplement the loss through weeping It may or may not be possible to make this up in a patient by peroral nourishment, where this is inadequate a supplemental or complemental diet must be furnished This consists of amino acids plasma or whole blood Where extremely large amounts of plasma are necessary say 4 or 5 pints a day it is better to administer amino acids In 250 cc of a 5 per cent solution of amino acids there is as much protein (12 5 Gm) as in an equal amount of citrated plasma and it is much more easily

TABLE 1 FLUID DIET FOR LONG TIME USE IN THE CARE OF PATIENTS WITH BURNS

CONSTITUENT	AMOUNT	CARBOHYDRATE GRAMS	PROTEIN GRAMS	FAT GRAMS	CALORIES
Skim milk	3,000 Cc	150	90	6	1 014
Skim milk powder	300 Gm	150	90	6	1 014
Protolysate*	150 Gm		120		480
Valentine's liver extract	30 Cc		5	1	29
Total volume about	3,300 Cc	300	305	13	2,537
1/12 volume in ounces	9 Oz				

(After Lund and Levenson)

* *Protolysate* is a brand of protein hydrolysate prepared for oral feeding by Mead Johnson Company

The necessity for high protein diets in *severely burned invalided or repeatedly* operated patients cannot be overemphasized It is basically a form of amino acid therapy, indispensable to the maintenance of adequate resistance, water and mineral balance, blood volume and renal function in the individual

Another situation where diet is important arises in the later stages (after the second week) of an extensive burn The nutritional problem at this time is mainly due to the loss of protein—the result of constant weeping of serum This may be as true of any other extensive superficial wound The problem remains as long as there is an open granulating surface Co

available, as easily given and much less *costly*

Where sufficient protein could be administered to the patient perorally, there still remains the question as to whether or not the patient actually consumes the entire amount of food prescribed The control of such patients and their dietary intake is frequently a difficult problem, even under close supervision, and particularly so if the patient is in a large ward Because of this difficulty Charles C Lund and Stanley M Levenson devised a supplemental feeding (Table 1) which in great measure circumvents this difficulty According to the authors the rationale of the feeding resides in this fact

The new diet consists of making the supplement the main diet and allowing the patient to eat any food desired at mealtime if he wants to A reasonable palatable, simple fluid mixture that contains all the food elements needed over long periods of time by the patient is the sine qua non of this procedure *

Lund and Levenson recommend that the foregoing mixtures be made up daily by the dietitian and stored in the refrigerator one-twelfth of the mixture is then given to the patient every 2 hours day and night, and someone then watches him drink it They further suggest that if the patient refuses the mixture gavage feeding is initiated at once

REMOVAL OF SUTURES

The careless or ill timed removal of sutures in plastic surgery is a regrettable act Removal of sutures by the surgeon on any day which seems particularly convenient for him is a poor habit The best time must be dictated by the condition of the wound The work should be done only by experienced and knowing hands especially with eyes orifices and children

Before any sutures are removed the incision or wound should be thoroughly inspected to determine its state of healing, the tensile strength of the closure and the capillary reaction about it This should not be done in an instant but systematically from one extremity of the incision or repair to the other Every unit of tissue included between every pair of sutures should be separately tested for healing

An incision does not always heal at the same rate throughout its extent Not infrequently it will be found that for one or another reason certain parts of the incision have lagged behind other parts The sutures in the lagging segments should be allowed to remain and should be removed only when signs of adequate healing are present Nothing is gained by spotty diastases of a surgical repair, except a beady looking scar, immediately discouraging to the patient

If at an early inspection of the wound it is found that an occasional suture is too tight and shows signs of tissue irritation, it is better to remove it too early than too late To avoid the consequence of too early removal of such a suture, one of the complimentary expedients of wound splinting, such as the collodion strip, can be substituted in its place Immediate removal of such sutures is as imperative as the removal of a foreign body, because the tissue reaction to it is the same

Since most suturing in plastic surgery is done with very fine material, and since the individual sutures are rather closely placed, a very definite and meticulous removal must be practiced First, one should identify the knot and then one of its free ends This should be securely grasped by mosquito hemostat or very fine tissue forceps and slightly but gently pulled upon until the suture is lifted just high enough above the level of the skin to permit the insertion of a fine sharp eye scissors It should then be cut as closely to the epidermis as possible The first cut must sever the suture By gentle traction at right angles across the incision with the hemostat the suture should be allowed to slip out The dramatic jerking of sutures out of the tissues is unwise It results in microscopic trauma to the skin, usually evidenced by slight oozing from the suture wound

The removal of sutures always leaves for a time a chain of minimal wounds Consequently, when the sutures have been removed the suture points should be touched with alcohol and dried This may be followed by painting the suture line with colorless Mercresin or compound tincture of benzoin, the field should be dried thoroughly If necessary, the entire suture line may then be supported or splinted by collodion strips or adhesive until one is certain that the wound is sufficiently organized to maintain itself against the pull of collateral

* Lund C C and Levenson S M The nutrition of patients with thermal burns Surg Gynec & Obst 80 449 1945

tissues or the exigencies of early function

A temperamental or fearful adult or a young child may make the removal of sutures a test of patience In such cases it is better to resort to some form of light anesthesia rather than to subject the patient to the anxiety and one s self to the ordeal of attempting to remove many fine sutures under impossible circumstances A good form of light general anesthesia for this purpose in children consists of a few drops of vinyl ether or ethyl chloride deposited on a small mask and held at some distance from the nose In adults recourse may be had to small injections of pentothal sodium If this is contraindicated or difficult intravenous morphine sulphate grain /6 to 1/4 may have to be used

For so called esthetic reasons it has become more or less the custom to remove sutures on the third or the beginning of the fourth day in plastic surgery This short lapse in time is not always sufficient for complete healing of relatively large wounds In fact by the third day the wound is still in the stage of adhesion rather than adequate cohesion The stage of healing nevertheless is sufficient for the wound to contain itself if some form of supplementary splinting is used For this purpose one can use strips of elastoplast or collodion secured gauze This should be followed by functional splinting as discussed in Chapter 19 Splints and Splinting

STATISTICS

The final postoperative conclusion of a case should include complete and final organization of all available records and data having anything to do with the patient This is particularly necessary in plastic surgery not alone because it is a good scientific habit but because it is the only means of reliable reference to dependable facts in subsequent procedures so frequently indicated in this specialty This practice is as important as the proper taking of a history and should include all available roentgenograms photographs written records moulages progress notes as well as laboratory records Where a series of operations constitutes the plan of correction this system is imperative The surgeon never should rely upon his memory in the scientific management of a case

The practice of final organization of all data pertaining to the origin the course and the conclusion of a case is a form of self discipline—the sign of a conscientious and wise surgeon

BIBLIOGRAPHY

Altshuler S S Sahyun M Schneider H and Striano D Clinical use of amino acids for the maintenance of nitrogen equilibrium J A M A 121 No 3 1943

Anderson G K The importance of protein in diet therapy J Am Dietet A 21 436 1945

Arnott G M and Young W F Postoperative fluid requirements of children Lancet 242 523 1942

Barborka C L Treatment by Diet Philadelphia Lippincott 1948

Bingham M R Nonadherent surgical dressings Arch Surg 52 610 1946

Brown J B Byars L T and McDowell F Preoperative and postoperative care in reconstructive surgery Arch Surg 40 1192 1940

Brunkow B H Embolic vascular accidents of the extremities Am J Surg (N S) 53 No 3 1941

Byars L T and McDowell F Preservation of jaw function following surgery and trauma Surg Gynec & Obst 84 No 4A 1947

Cordier G et Demurleau J L utilisation du plasma ou serum animal chez l homme plasma ou serum universel detoxique Presse med 54 883 1946

Co Tui F W The value of protein and its chemical components (amino acids) in surgical repair Bull New York Acad Med 21 631 (2nd series) 1945

Co Tui F W Wright A M Mulholland J H Barcham I S and Breed E S The nutritional care of cases of extensive burns Ann Surg 119 815 1944

Co Tui F W Wright A M Mulholland J H Carabra V Barcham I and Vinci J V Studies of surgical convalescence Ann Surg 120 09 1944

Craig W M Shock J Internat Coll Surgeons 7 No 2 1944

DeBakey M Giles E J and Honold E The protection of the operative field with an impermeable adhesive skin coating Surg Gynec & Obst 74 499 1942

Elman R Weiner D O and Bradley E Intravenous injections of amino acids (hydrolyzed casein) in postoperative patients Ann Surg 115 No 6 1942

Fallis L S The management of postoperative wound separation Surgery 9 198 1942

Fisher H E Non adhering surgical gauze dressing J A M A March 25 1916 p 939

Green R Biochemical aspects of preoperative and postoperative treatment Its practical application Am J Surg (N S) 54 No 3 1941

Holden J C and Crile G Jr Influence of vitamin B complex deficiency and partial starvation on wound healing Experimental research with rats Arch Surg 44 1106 1942

Holinger P H and Loeb W J Feeding Tube Stenosis of the Larynx Surg Gynec & Obst 83 253 1946

Jentzer A Traitement biologique des infections Paris Masson 1928

Kiskadden W S and McDowell A J Wet dressings in plastic surgery Plast & Recon struct Surg 3 No 5 1948

Letterman G S Plexiglas splints their use in pedicle flap attachments Plast & Reconstruct Surg 3 No 5 1948

Lexer E Weiderherstellungs Chirurgie Leipzig Barth 1920 p 360

Lustig B Goldfarb A R and Adlersberg D Distribution of proteoses and peptones after intravenous injection Proc Soc Exper Biol & Med 58 No 2 1945

Mandl F Adult tissue extracts in promotion of wound healing J Internat Coll Surgeons 7 No 1 1944

Mayo C W Pre operative and post operative care of the surgical case Material Presented at Postgraduate Conference DuQuoin Ill March 1940 Ill State Med Soc

Meleney F L The topical use of antibiotics in established surgical infections Surg Gynec & Obst 86 No 6 1948

Meleney F L and Harvey H D Treatment of chronic undermining burrowing ulcers due to micro-aerophilic streptococcus Ann Surg 110 1067 1939

Moyer C A Fluid and electrolyte balance Surg Gynec & Obst 84 No 4A 1947

Owens Neal Rayon an ideal surgical dressing for surface wounds Surgery 19 482 1946

——— Use of pressure dressings in the treatment of burns and other wounds S Clin North America Oct 1945

Padgett E C The late care of severe injuries of the face and jaws Surg Gynec. & Obst 72 437 1941

Parker J M The changing concept of preoperative and postoperative care J Maine M A. 38 231 1947

Pueston C B Relation of dietary deficiencies to surgical convalescence Bull Am Coll Surgeons April 1940

——— Vitamins and surgery Collective review International abstract of surg Surg Gynec & Obst 70 195 1940

Robinson W Ammonium bicarbonate secreted by surgical maggots stimulates healing in purulent wounds Am J Surg (N S) 47 No 1 1940

Shipley E R and Dodd M C Clinical observations on furacin soluble dressing in the treatment of surface infections Surg Gynec & Obst 84 No 3 1947

Speir E B Symposium on the use and abuse of bed rest West J Surg 54 325 1946

Stewart J D Postoperative shock due to hemolytic streptococcus wound infection Surgery 9 204 1941

Tinker M B Davis J S Kraissl C J Lyons C and Lockwood J S Postoperative infections Panel discussion clinical congress of the American College of Surgeons Philadelphia Pa Oct 20 1939 Internat Abstr Surg (Surg Gynec & Obst) 71 403 1940

Trueman K R Early postoperative wound disruption Canadian M A J 57 550 1947

Wyss O Rubin M and Strandskov F B Mechanism of sulfonamide action III Biological action of substituted p-aminobenzoic acids Proc Soc Exper Biol & Med 52 155 1943

SECTION TWO

PROBLEMS

15

Original Repair

Original repair constitutes considered biophysical management of a recent wound. Surgically, there are three types of such wounds: those purely a matter of tissue derangement, those essentially characterized by a tissue void and those a combination of derangement and tissue absence. The essential purpose of adequate original repair is the propitious establishment of conditions most favorable to functional healing and good formative results insofar as the nature of the injury and the exigencies of the case permit. It is the only time and often the only opportunity for the assurance of adequate healing and satisfying functional results. This opportunity may be present when the case is first seen by the surgeon, if gross contamination is not a problem; otherwise it may have to be done on the fourth to the ninth day, depending on the condition of the patient.

Such repair of an acute injury is a test of physiologic thinking, surgical ability and good judgment. The bungling of this opportunity is one of the most frequent causes of deformity and subsequent invalidism. Inadequate or careless original repair is a kind of original sin, the price of which is prolonged hospitalization, pain, protracted healing, prolonged convalescence, scarring with deformity and often in no small measure eventual personal embarrassment to the surgeon.

TISSUE WOUNDS

An important tissue wound presents a situation which may be divided into four major phases: the preservation of life (first-aid surgery), the conservation of the patient as a physiologic unit (treatment of patient), the general care and evaluation of the wound (treatment of the wound) and restoration of functional tissue continuity (original repair). It is a tempting but serious mistake to dive head first into the depths of a wound at the expense of the general welfare of the patient. Such practice stamps the operator as a surgical ostrich. Intelligent original repair must be based upon and preceded by proper first aid care, a physiologic patient and adequate general care of the wound. Otherwise it may be done too early and can be done too late.

First Aid Surgery

The most imperative thing in an acute injury is the control of hemorrhage and the securing of adequate respiration. Hemorrhage always should be thought of in both its external and internal forms. It is not rare for a severe internal injury to the thigh, without any evidence of an external wound, to result in sufficient laceration and intrafemoral bleeding to lead to death. It is equally possible for a relatively minor external laceration of the face to be associated with injury to deeper structures, serious enough to lead to acute interference with respiration. Barring the probability of immediate internal hemorrhage or interference with respiration, one must always remember the possibility of delayed hemorrhage, particularly so in trauma of the chest or the face. These are frequently associated with edema of the air passages leading to *obstruction of respiration*. The control of vital bleeding and maintenance of an ade-

Fig 78 Patient in shock following extensive second degree burns of face and all extremities by superheated gasoline fumes He was conscious alternately alert and drowsy joked and asked for cigarettes never complaining of any discomfort Shock was diagnosed and the patient was treated accordingly He stayed alert and feeling fine for hours Then lost ground rapidly and death followed 13 hours after injury in spite of general therapy due to rapid severe pulmonary edema

quate airway is important enough so that in case of severe necessity these may even supersede aseptic precaution and functional concern

Treatment of the Patient

In a severe tissue injury the whole patient has been hurt One never must be fooled by the patient's appearance attitude expression of feelings or conversation (Fig 78) It is safer to rely on proven clinical and laboratory facts whose silent evidence is far better proof of the individual's general condition This is particularly true of a patient in shock

Shock Shock is a state of physiologic decompensation of the injured individual characterized by such clinical findings as profound drop in blood pressure ashen color of the skin cold clammy sweat apathetic attitude pallor rapid pulse of poor volume subnormal temperature sluggish pupils and depressed tendon reflexes This condition is usually divided into primary and secondary or true shock

Primary Shock Primary shock is an acute psychosomatic syndrome associated with sudden physical insult It is essentially of neurogenic origin precipitated by fear and pain and ordinarily passes off in from a few minutes to about two hours if the patient is kept quiet unirritated painless and warm Although relatively transient in duration it varies in severity according to the susceptibility of the individual to pain and other sensory stimuli It is a clinical syndrome consequent upon the temporary loss of vasomotor control leading to embarrassing generalized vascular relaxation

Secondary Shock Secondary or true shock is a form of complete physiologic collapse Where for one or another reason vasomotor control is lost and cannot be re-established or maintained a profound generalized circulatory decompensation will result leading to loss of blood plasma into the tissues basically due to abnormally permeable capillaries This may become fatal within the space of a few hours unless energetically combatted by adequate counter measures

Once it has been determined that the patient suffers from true shock he must be handled very cautiously He must not be disturbed any more than is consistent with necessity and treatment of the condition Clothes should not be haphazardly removed Incisions in the apparel should be made over such regions as are necessary to proper therapeusis The adequate treatment of shock is still a moot question Neverthe

less, clinical experience and observation of the symptomatology permit certain generalizations

The treatment of true shock should begin immediately The choice of sedative depends to a great extent upon associated clinical conditions Generally morphine sulphate, 1/4 to 1/2 gr may be used but even this may be dangerous in the presence of anoxia The barbiturates are contraindicated in individuals who have a history of sensitivity to the drug or are known to suffer with hepatic or renal damage Electrolytes should be given as soon as possible particularly where there has been considerable vomiting or mineral depletion From 5 to 10 per cent glucose in saline or sterile water with or without ascorbic acid vitamin B complex and sodium bicarbonate is the standard procedure On the other hand overdosage with the electrolytes must be guarded against particularly where there is a greater loss of blood serum rather than whole blood as is the case in extensive burns In such conditions it is better to give plasma which eventually should be followed by whole blood If the shock is obviously deep the first dose of 500 cc of plasma should be given rather rapidly whereas all subsequent doses should be given slowly

Calculating Plasma Dosage There are several methods of estimating the amount of plasma needed One method is to give 100 cc of plasma for each point over 45 of the hematocrit estimation (H N Harkins) Another method is to determine the amount of plasma lost in terms of liters in accordance with the following formula HB 100 5 (5 X) HB is the observed hemoglobin and X represents the amount of plasma lost in liters In actual practice the formula works out better if the figure 90 is substituted for the figure 100 since the formula assumes that the patient had a hemoglobin of 100 per cent before the accident A third method is to determine the percentage of body surface involved by one or another means, such as Berkow's (see Fig 171 in Chap 17) and then administering 50 cc of plasma for each one per cent of raw area

Where plasma is not available or is impossible to give serum may be given in normal strength or in concentrated form Two times or four times concentrated serum is advocated by some authors and is frequently followed by dramatic recovery from profound shock However, its effect is less permanent than that of normal strength serum Twice concentrated serum is more easily administered than the four time concentrated form and can be repeated when indicated Rarely is it necessary to repeat it more than twice according to S D Gordon and R A Gordon

In the treatment of shock the temperature respiration and hemoglobin should be taken every two to three hours regularly and the blood pressure every 30 minutes for the first 24 hours Coincidentally provisions should be made against tongue swallowing which occasionally occurs and is very embarrassing or may prove to be disastrous

Where shock is obviously due to actual hemorrhage rather than escape of plasma into the tissues infusion of whole blood in place of serum plasma or electrolytes, is imperative Even in conditions where there is no obvious and frank loss of blood infusions of electrolytes and plasma should not be continued too long In severe burns for instance sooner or later there is extensive destruction of red blood cells so that infusion of anything but whole blood is inadequate Coincident with the infusion of whole blood in the foregoing type of case, oxygen should be given freely Where the loss of blood is not extreme from 8 to 10 liters of oxygen may be sufficient to cope with the problem

Whatever the measures chosen in the treatment of shock, they must, in principle restore the circulatory volume, augment the rate of the circulating blood, prevent anoxemia assure the ablation of pain and maintain body temperature

FIG 79 Number of foreign bodies (right of wound) removed after thorough irrigation of cranial wound They were not located at the time of the original repair

Certain don ts in the treatment of shock should be kept in mind

1 Do not disturb the patient any more than is absolutely necessary and consistent with intelligent therapeusis

2 Do not overheat the patient with hot water bottles or lights but rather maintain and control the body temperature at some what above normal

3 External body heat over 104° F never should be applied

4 Unless proven indications exist do not give over 4 000 cc of electrolyte in the first 36 hours

5 Do not give plasma too slowly in profound shock

6 Do not overstimulate patient with drugs

7 Do not give whole blood too early or too late—but better early than too late

8 Do not hesitate to give whole blood and oxygen if the patient does not respond to any other type of infusion within 6 to 8 hours

TREATMENT OF THE WOUND

Hemorrhage The most imperative single element in all wounds is the immediate control of bleeding In frank hemorrhage this may even supersede in importance the necessity for immediate care of the patient as a whole In unusual instances such as finding a patient with a severed carotid artery and no surgical instruments at hand it may be necessary to grasp the bleeding vessel with one s bare fingers Under ordinary circumstances all bleeding vessels should be grasped by sterile hemostats Less dramatic bleeding is controlled by ligation with 3/o or 4/o catgut or #60 to #80 cotton Oozing may be controlled by pressure or impact irrigation The latter consists of spraying the wound forcibly with sterile water or saline either under pressure or from a height of approximately 18 to 20 inches The impact of a fine water spray against an oozing surface usually stops the bleeding in a minute or two The control of oozing from bone or muscle is particularly troublesome at times but must be accomplished absolutely

Asepsis The avoidance of infection in wounds is the basis of all modern surgery It is a gross technical error to plunge into the examination of a wound without proper masking and covering of both the surgeon and the patient himself It is not unusual to see operating room personnel exert all efforts in the establishment of general asepsis and at the same time witness the patient talking coughing or sneezing throughout the care of an extensive wound This unfortunate occurrence is probably more common in the management of extensive burns than in any other type of wound It is poor surgery

The prevention of infection involves the removal of all foreign bodies including blood clots (Fig 79) irrigation and final hemostasis with intelligent debridement and occasional chemotherapy These will be discussed under their proper headings

Physiologic Toilette With hemorrhage controlled and asepsis established wound toilette follows All substances must be removed from the depths of the wound which

Fig 80 (*Left*) Metallic foreign body overlooked at original care of neck wound, due to lack of adequate exploration, because wound seemed to be insignificant Patient could open mouth only one-half cm (*Right*) Cervical scar is original point of entry of overlooked foreign body shown at left Incision over lower border of mandible is point of surgical entry for removal of metallic body which lay deep in pharyngomandibular fossa

in any way may contribute to the development of infection, the interference with healing, or the causation of pain, dysfunction and deformity. This should begin with thorough irrigation of the wound with sterile normal saline It is not sufficient to wipe a wound casually or to pour some water into it nonchalantly, assuming that the wound has been irrigated These are homely truths too often disregarded.

The injured part should be placed in such position that irrigation can proceed from the depths of the wound outward. The inclination of the wound, if at all possible, should be of such an order that there is immediate drainage of the irrigating solution from within its depths and preferably in one direction This avoids the whirlpooling of matter within the wound, the constant in additional trauma and very little actual cleansing. The irrigation of a wound, other things being equal, should continue until there is a definite blanching of the tissues. Then the injury should be carefully and thoroughly dried for inspection.

One important feature in the irrigation of a wound never must be forgotten, namely, that in extensive lacerations there are recesses into the injured tissues or separations of the cleavage lines between tissues which may and usually do harbor foreign material (Fig. 80). Therefore, all wounds in the course of irrigation should be gently but thoroughly dilated or retracted in order to make certain that the irrigating substance reaches all recesses of the tissues.

Inspection. Detailed original inspection of a wound is the most important single

wound until the end of the third day or the beginning of the fourth

Whatever the time auspicious for the repair, its ultimate purpose is adequate functional reconstruction This, reduced to a common denominator implies two things atraumatic anatomic repair and functional splinting

The degree and the method of closure of a wound depend upon its nature In other words, did the injury produce only disturbance of tissue relationships and tissue continuity (derangements), or is there actual loss of tissue (void)? Most extensive wounds, of course are a combination of the foregoing (Figs 81 83)

If an actual tissue void exists the probability of adequate functional closure is reduced to a minimum This is particularly true in injuries of the exposed parts of the body, such as the face and the hands To close such a wound forcibly is to add insult to injury It is far better in such cases to replace the remains of severed tissues in as normal an anatomic position as is consistent with the findings, cover the wound with a permanent biologic dressing (a split skin graft) and accept the necessity for later reconstruction Where a tissue void exists, either because of maceration or actual loss early reconstruction is more dangerous than the deferred type because in such wounds contamination more easily develops into infection, than in wounds where only loss of tissue continuity exists This is particularly true with muscle voids

Where thorough inspection has revealed that no actual tissue void exists but that the wound is one of loss of continuity through laceration or fracture, the main object is the re establishment of anatomic integrity This should and must only be attempted in surgically clean wounds Otherwise, though the wound as a whole may stay closed, the ultimate functional success of the repair will be compromised Where the loss of continuity of specific tissues is a clean one, both anatomically and bacteriologically, immediate suture thereof, provided that there is absolutely *no tension*, is permissible This applies equally to nerves, muscles, and tendons, as well as to blood vessels Where it is impossible to reconstitute the anatomic continuity of tissues without tension, it is far better to replace such tissues in their normal polarity within the wound, secure them lightly with appropriate suture material for purposes of splinting and subsequent allocation and proceed with the closure of the remainder of the wound To be tempted to do otherwise is to induce deliberate surgical deformity, which is worse than no closure at all Such forceful closure only leads to additional fibrosis and subsequent dysfunction, making final reconstruction more difficult, if not impossible It must be obvious by this time, that the old fashioned "mass closure'

Fig 82 Moulage of extensive traumatic facial loss and tissue derangement (War injury) No immediate repair possible although patient was not in shock White central area represents gauge packed into traumatic cleft involving lip, palate, nose and left orbit Subsequent reconstruction involved 22 separate procedures

FIG 83 Tissue derangement consequent upon forcible closure of extensive chin wound with loss of mandibular symphysis (see Fig 84)

of wounds is a functional heresy, indefensible in the light of modern knowledge

Most major accidental wounds present both of the foregoing elements (derangement and void) for consideration It is the degree to which anyone of the two is present which determines the seriousness of the wound This and the location of the wound dictate the type and the extent of the closure which is wise and possible (Fig 84)

Biologic vs Anatomic Wound Closure No matter what the nature and degree of a wound if it can be closed only under tension or if it has been received in a contaminated state it is dangerous to do a reparative closure In the first instance the repair will result in fibrosis and disfunction in the second probable complete breakdown will follow as a result of infection Therefore if conditions anatomic and bacteriologic are not obviously present, permitting safe repair and its maintenance, biologic closure is the better choice This consists of thorough irrigation, drying and cautious debridement with skin coverage via a thin split graft This graft with two or three small perforations in the dependent portion for drainage, will live and "take" in a relatively contaminated wound This will accomplish closure where repair is impossible, also, it will prevent extensive fibrosis and tissue retraction It will make late repair easier and more promising than a wound healed by extensive scar formation (Fig 85)

Original Repair of complex wounds is discussed following "Specific Tissues"

ORIGINAL REPAIR OF INJURIES TO SPECIFIC TISSUES

Skin

Derangements Insofar as they exist from the standpoint of the plastic surgeon,

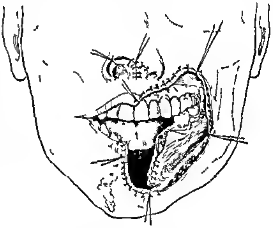


FIG 84 Extensive loss of lips, left cheek, mandible and right ala, with proper first aid surgery The mucosa of cheek and nostril are approximated to skin The lingual mucosa of the fractured mandible is approximated to the buccal This closes all raw surfaces The fractured segments of mandible are then splinted to uninjured maxillae to prevent collapse This avoids complete derangement of facial tissues (Adapted with modifications from Matthews)

are accidental afflictions of the body cover involving the epidermis the derma or both

ABRASIONS AND MOST DISCOLORATIONS may be considered together because they basically involve only the epidermal layers of the skin which in the first instance, with *proper protection will heal without any* scarring and in the second instance with time will disappear because of the normal desquamation of the epidermis In simple complished only by complete exclusion or some compensatory tattooing with dyes whose color approximates that of the surrounding untattooed skin The application of all types of escharotics for the purpose of blistering the skin and the more recent *procedure of repeatedly removing* the epidermis via the dermatome are respectively unsurgical and unphysiologic In the first instance insult is added to injury by the

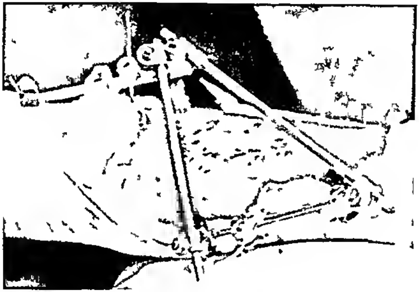


FIG 85 Extensive comminuted fracture of tibia with large loss of overlying soft tissue The wound was debrided irrigated and dried Bone fragments were then splinted as shown Plaster of Paris was applied and thin split graft (biologic dressing) was basted into the wound and splinted via bundle dressing Photograph was taken at time of first postoperative dressing (10 days) Note complete closure of compound wound and ease of approach to dressing of graft

abrasions certain substances such as scarlet red may be used to advantage because at least clinically they seem to have a stimulating effect upon the generation and growth of new epidermis and, secondly, because when incorporated in petrolatum they act as good protective coverage for the abrasion Protection of the denuded derma is all *that is necessary in the treatment of skin* abrasions This includes protection from chemicals

TATTOOS are relatively permanent skin defacements Their eradication can be ac-

escharotic The tattooed skin, because of the additional irritation sooner or later becomes permeated by considerable fibrous tissue in addition to the already present foreign bodies In the second instance, the procedure is inadequate because tattoos usually involve the deeper layers of the skin therefore, the removal of the epi*dermis is insignificant in* the ultimate cure of the condition Finally repeated decortication of the skin unavoidably leads to eventual sclerosis due to deposition of fibrous tissue in the derma Even if one

where the void involves more than skin and subcutaneous tissue but it accomplishes the first thing necessary in the rehabilitation of the part namely closure of an open wound without tension This type of wound closure is nevertheless far preferable to that accomplished by the free skin graft because it allows for eventual re entry and deep grafting (bone) which is not possible in a closure done by means of a free graft

FIG 88 Traumatic ulceration associated with fracture of tibia and fibula foreign body and fistula over Achilles tendon Granules about ulcer are sulfathiazole Note edema of ankle and neurocirculatory involvement of soft tissues at level of fracture Definitive repair contraindicated Closure of wound by split graft necessary pending resolution of soft tissue involvement (see Fig 89)

FIG 89 Same case as Figure 88 after excision of ulcer and application of thin split graft (a permanent biologic dressing) Note disappearance of edema after wound coverage (3 weeks postoperative)

SECOND DEGREE BURNS are those associated with the formation of bullae or vesicles and usually need no other surgical intervention except protection of the vesicles from infection their eventual evacuation and the ultimate removal of the dead outer skin so as to give the underlying derma an opportunity to epithelialize without maceration (Fig 91) If after removal of the necrotic overlying skin the underlying derma is properly protected from injury there should be little fear of permanent scarring On the other hand if the vesicles over the injured derma become infected or are permitted to be undrained for long periods so that maceration of the ingrowing epithelium results or where after decortication of the underlying derma the latter is injured by inappropriate dressings or the application of irritants permanent scarring may result (Fig 92) (cf Chap 20)

VOIDS AVULSIONS True skin avulsions are not as common as the compound type consisting of skin and subcutaneous tissue and tissues beneath the facial planes Nevertheless skin avulsions per se occur and involve the full thickness of the organ

When full thickness skin is accidentally avulsed from its underlying structures it is more difficult to count on its survival after replacement than if separated with its subcutaneous tissue In the former case if it is

a clean injury, its replacement is subject to all the difficulties and the advantages encountered in a full thickness skin graft. The results obtainable are parallel with the exigencies of full thickness transplants. In the second case survival of the skin is aided by the deep circulation from the subcutaneous tissue particularly where the residual attachment of the avulsed tissue is proximal. In such an instance the tissues can be treated on the same basis as a single pedicle flap. Of course, where the avulsion is a total separation of tissue from the body, it cannot be replaced with any hope of success unless the fat is removed and only the full thickness skin is replaced, as in a true skin detachment (Fig. 93).

In any case all the basic principles pertaining to tissue transplantation must be applied here.

Losses. True skin losses of an amputative nature must be handled in one of three ways. Where the detached skin can be recovered uncontaminated, which is unusual, it can be replaced and must be treated as a free graft. Where it cannot be recovered or employed if recovered, the wound can be closed either by inshifting of French flaps or the application to the defect of a split graft from a donor site. If the skin loss has been sustained under obviously septic conditions, closure by either means must be delayed until the wound is at least clinically clean.

Third-degree Burns. Skin voids the result of third-degree burns are far more common than the preceding types. These are discussed in detail in Chapter 20, The Surgery of Burns and Their Consequences.

Fig. 90. Immediate closure of compound fracture of tibia after debridement by medial rotation of French flap from lateral aspect of leg to cover site of fracture. Donor site was free-grafted (full thickness) from secondary donor site on medial aspect of thigh (12 days postoperative). Contrast with Figure 96.

Subcutaneous Tissue

Injuries to the subcutaneous fatty tissue are almost always associated with or secondary to injuries of the skin They may be divided into derangements and voids The former are the more common

Derangements CONTUSIONS The most prominent consequence of fatty contusions is subcutaneous hemorrhage and possible fatty necrosis If one of the vessels of the deeper circulation in the fatty tissue is injured it results in a subcutaneous hematoma The basic treatment in either condition is cold pressure and immobilization If these are inadequate because the subcutaneous vessel is a large artery incision and ligation of the vessel may be necessary

FIG 91 Second degree burn of left lower extremity due to superheated steam Note fluffed cotton envelopes into which extremity is being placed to avoid pressure or abrasion of vesicles on thigh and which are clear and uninfected A large purulent vesicle lateral to the patella has just been excised and cleaned

FIG 92 Superficial ulceration on medial and posterior aspect of right knee due to undrained infected vesicles in second degree burn Vesicles should always be opened when showing signs of infection never when clear and uninfected

FIG. 93 Avulsion of forehead and left temporal region. Replaced without complications. Narrow peduncle of forehead flap carried sufficient blood supply from left supra-orbital artery (as shown, after secondary revision of puckering).

LACERATIONS. True laceration of subcutaneous fat is almost without exception associated with open injury of the skin. All lacerations involving fatty tissue must be minutely inspected for tags of free fat, which should be removed even though not completely severed within the wound. This is so because the circulation within the fatty lobules is not as adequate as that in other tissue units and secondly, because even architectural disorganization of subcutaneous fat is sufficient to result in liquefaction and loss. Therefore, it is well to remove it immediately, since closure of the wound runs the chance of postoperative oleoma. The approximation of lacerated fatty tissue should be done guardedly, with as few sutures as possible and with absolutely no tension on the fat. Where large masses of fat have been lacerated it is far better to approximate the two lips of the fatty laceration by fine sutures passed through the facial investments as well as the lips of the wound.

In extensive lacerations of fat one always must bear in mind that secondary postoperative hemorrhage is pre-eminently common. Hence, at the time of repair all bleeders, large and small, must be absolutely controlled, and postoperative pressure dressings must be insisted upon and maintained for at least 52 hours.

Voids of fatty tissue may be primary or secondary. Primary voids are always associated with overlying skin loss, and their management is the same as that accorded skin avulsions.

Secondary voids are those following contusive or operating trauma. This leads to fatty necrosis, liquefaction and finally extrusion or absorption of the fat. The fat is then partially replaced by fibrous tissue, whose shrinkage leads to shallow depressions. (For repair, see Fig. 10.)

FASCIA

Fascial injuries may also be divided into derangements and voids. Under the former belong diastases and lacerations. Since their original repair is basically the same, they will be discussed together.

Derangements. LACERATIONS of the fascia may occur without any external wound and are usually due to excessive force exerted against or upon the fascia when under tension. This force may be the result of muscular action, or of severe contusion from a blunt instrument from without. In the latter case the fascia is usually in a state of separation in the axis of its grain, whereas in the former case it may be an actual tear

across the fibers of the fascia In separations of the fascial grain due to stress and strain, there is usually concomitant herniation of the muscle tissue beneath, and where the fascia overlies bone or joint there is definite and immediate painful interference with function Where the laceration or the separation of the fascia is complete, and particularly where associated with external wounds, it may be repaired by direct approximation, if the wound is fresh and surgically clean Where this is not the case, it is far better to enlarge the opening to allow for drainage and avoid embarrassment of collateral tissues from posttraumatic edema and constriction Where lacerations in a fascia are of such an extent that direct approximation is not possible, it may be necessary to mobilize fascial grafts from other regions to be used in the repair Where this is not feasible, grafts of derma may be used to supplement the defect in the fascia

Voids may be the result of operative removal or gross avulsion In the former unless they lead to muscle herniation no repair is necessary If herniation does occur the fascial defect may be enlarged to decompress the underlying muscle and so relieve constriction of its circulation and painful function If this is inadequate, repair via dermic graft may be done

In gross avulsions of tissue with loss of fascia, the same management is indicated as that following surgical removal

Muscle

Derangements Contusions The most important clinical feature of muscle contusion is intramuscular hemorrhage This produces a separation of muscle fibers or bundles, resulting in swelling, pain and dysfunction If the bleeding is not controlled by pressure dressings it may assume proportions, leading to pressure necrosis, fibrosis and loss of function

Lacerations of muscle are almost always associated with external wounds of the skin and often are due to perforating objects, such as knifes, bullets, glass or shrapnel Lacerated muscle always must be removed as soon after the injury as possible, since its powers of regeneration and resistance to infection are extremely poor, and its normal contractile powers are almost completely lost within three or four days after the injury Intramuscular pockets never must be allowed to exist postoperatively because these are notorious for the development of gas gangrene Complete and immediate closure of the superficial tissues over an extensive laceration of the muscle is not recommended Saucerization is the better plan because of the possibility of formation of foci of infection within the covered pockets All extensive muscle lacerations must be allowed to heal from the bottom out All wounds involving muscle must be stabilized and splinted for a period of time consistent with the formation of adequate granulation tissue Only then is the danger of a spreading infection in and about the muscle excluded When that time arrives the saucerized wound may be excised and free skin grafted until such time as reconstruction is possible Where conditions permit, the granulation tissue may be excised, the walls of the defect freshened and the wound reconstructed as a problem in original repair

Voids of traumatic origin to muscle are always a serious matter because of their crippling consequences and difficulty of repair Such losses may be compensated for in one of two ways by substitution of fascia, or a portion of neighboring muscle Where only partial loss is sustained near the muscle origin or insertion, fascia may be an adequate substitute But where the loss of muscle substance is such as to destroy its overall function only muscle substitution is adequate

Nerves

Derangements Contusions may or may not be associated with open wounds They may result in paresis of innervated struc-

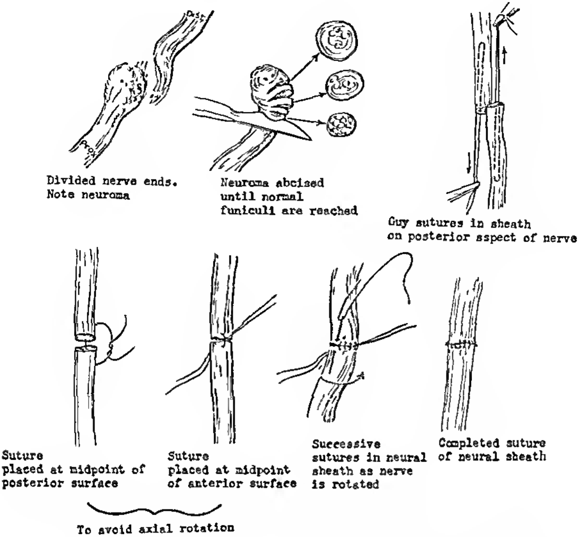


FIG 94 Method of freshening and suturing of trans sected nerve after development of neuroma Sections of nerve ends should be done with razorlike blade, thin abscissions being made until normal nerve tissue is recognizable (Redrawn after Tom Jones)

tures at times leading to the suspicion that the nerve is severed This is not uncommon in nerves subjacent to the skin and coursing over bony prominences Treatment of these conditions is not relevant here

LACERATIONS Where conditions permit, immediate suturing of a transsected nerve trunk is the ideal form of surgical treatment Where this is not possible, the nerve ends should be identified and focalized for future repair by easily recognizable fine suture material such as horsehair black silk or wire Where subsequent repair of an injured part is necessary, direct suturing of the severed nerve ends may be done at that time This is preferable to later free grafting, even though the part involved may have to be placed in an afunctional position and splinted for a comparatively long time (Fig 94)

VOIDS It is rather well agreed that the free grafting of voids in severed nerve trunks, at least thus far, remains a guarded, if not questionable, procedure Certainly the use of nerve homografts has been a very disappointing surgical adventure

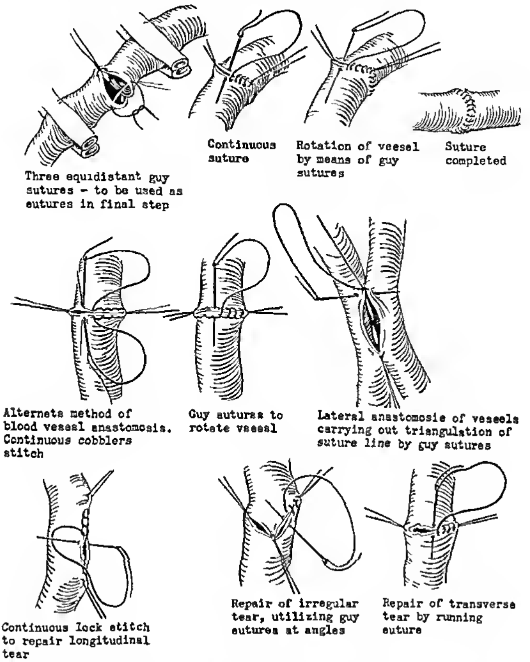


FIG 95 Carrel method of suturing severed blood vessels (Redrawn after Shepard)

Blood Vessels

Derangements Contusions of blood vessels, even of a large caliber, do not present any immediate operative concern But they do pose the problem of sequelae and complications, such as secondary hemorrhage due to necrosis of the vessel wall, thrombosis with gangrene of the part nourished by the vessels, eventual hematomas, *aneurysms*, or *arteriovenous fistulae* Where a contusion of an important blood vessel is suspected, the case must be watched carefully for clinical signs of any of the above complications When they arise they must

Fig 96 Results of poor management of compound fracture of tibia (done elsewhere) Although soft tissues were debrided the wound was left exposed until the bone died Granulations sloughed and an attempt was then made to regranulate bone surface by drilling This was too superficial to yield adequate results (For reconstruction see Chap 29) Contrast with Figures 90 97 98 99 and 102 Figure 102 shows manner of one stage closure of this case

be treated as conditions permit The age of the patient the surgeon's mental and technical equipment the part involved and the armamentarium available—all influence the treatment of such complications

Punctures and Lacerations Actual puncture or laceration of a blood vessel if only partial is usually amenable to simple suture followed by the use of preparations recommended against postoperative clotting (heparin etc) in the region of the repair (Fig 95)

In the complete laceration of a blood vessel little further progress has been made with methods of repair since the Tuffier tube to re establish continuity of the vessel and to maintain normal circulation Insertion of metallic tubes such as those made of vitallium or tantalum and lined by segments of vein or other material have been tried without the hoped for results The technical exigencies as well as the surgical difficulties of a badly lacerated artery usually preclude the use of such materials Even if mechanically successful there is still the problem of postoperative thrombosis the control of which has never been adequately resolved

Payr in 1900 recommended a prosthesis of magnesium chosen as an absorbable metal over which the ends of severed blood vessels could be ligated intima to intima The method was tested experimentally and clinically during the next few years (Hopfner 1903 Lexer 1907) During World War I attempts were made to join the ends of severed arteries by means of silver cannulas (the Tuffier tube) Gas cysts had been described by Hopfner in unsuccessful experimental cases undoubtedly a tissue reaction to magnesium These may have discouraged further trial of the method

In 1942 Blakemore Lord and Stefko reported their technic for nonsuture anastomosis of severed arteries and suggested that it could be applied to arterial wounds incurred in combat The prosthetic tubes were made of vitallium The technic was used in thirteen cases in World War II and reported upon by Simeone as follows (1) Nonsuture anastomosis should not be done if it cannot be accomplished without de

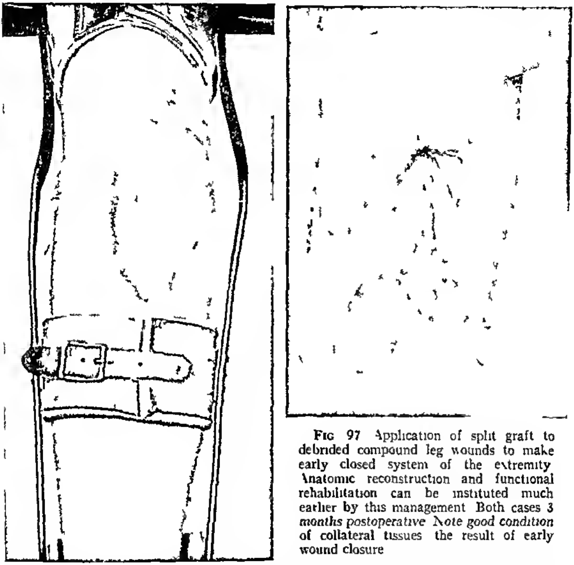


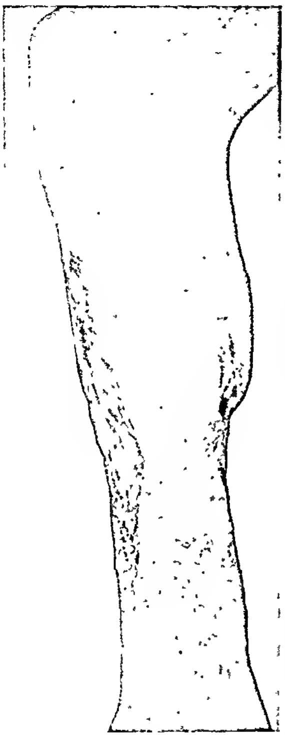
FIG 97 Application of split graft to debrided compound leg wounds to make early closed system of the extremity Anatomic reconstruction and functional rehabilitation can be instituted much earlier by this management Both cases 3 *months postoperative Note good condition* of collateral tissues the result of early wound closure

stroying important collateral circulation (2) *The nonsuture anastomosis may find* greater applicability to vascular surgery among civilians than among battle casualties because of the shorter time lag to surgery and the generally less extensive nature of the wounds among the former

The repair of blood vessels by direct *suture of the severed segments is rarely* practicable even in peacetime let alone in war Finally few surgeons are technically prepared to undertake such a meticulous repair Consequently ligature of the injured vessel with minimum interference with peripheral circulation is still the standard and *most reliable treatment in the majority of* cases To quote R W McNealy

Experience convinces one that too much emphasis cannot be placed on the fact that in the majority of instances the best interests of the patient will be served by conservative obliterative types of ligature or suture The more spectacular restorative suture which requires infinitely greater technical ability exacts a high toll of lives in the event of failure and *should be used only under the most favorable* conditions *

* McNealy R W Blood vessel surgery J Internat Coll Surgeons 5 363 1942



Voids in large blood vessels remain a problem awaiting solution The problem arises not so much out of the difficulty connected with the physical transplantation of vessels as with the immediate physiologic consequences. Maintenance of immediate function and prevention of thrombosis within the transplanted segment is the crux of the problem (For information in connection with the free-grafting of arterial voids, see Chap 17, "Arterial Grafts ")

Bone

Derangements. Bone derangements consist of contusions and fractures These may be simple or compound, with or without loss of substance. The injuries involving bone, which are of greatest interest to the plastic surgeon, are those associated with extensive loss of the overlying soft tissue. It is well agreed among surgeons that the best management of a compound fracture associated with loss of soft tissue and at times with loss of bone as well, is the reduction of the compound into a simple fracture and a closed wound as soon as possible (Fig 96). This should be preceded by or associated with thorough débridement, which includes conservative removal of jagged bone ends as well as soft tissue. This is followed by immobilization with proper postoperative care.

With the advent of chemotherapy in the form of penicillin, streptomycin and sulfonamides, it is possible to set up and splint compound fractures so as to make re-dressing of the wound an infrequent necessity. This is an important and intelligent addition to modern treatment. On this basic principle depends the closed plaster treatment of such injuries. With the lapse of from seven to twelve days, if no infection

Fig 98 Complex wound of lower extremity. After débridement, occlusive dressing was applied for 70 hours, and the leg was splinted. No clinical signs of infection appeared. The dressing was then removed, the wound was thoroughly irrigated; foreign bodies were removed, muscle, fascia and nerve were sutured; and split-skin grafts were applied as shown Systemic penicillin was used Picture taken 28 days postoperatively (see Fig. 99).

Fig 99 Roentgenogram of the patient shown in Figure 98 Note the extent of bone loss and the presence of foreign bodies

is present, granulation tissue will appear in the wound The latter is then free grafted to make a closed wound out of an open wound (Fig 97) With the lapse of six weeks or more, functional restoration or reconstructive surgery may begin (see Chap 17, 'Grafts Other Than Skin,' section on 'Bone Grafts," as well as Chaps 28 and 29)

Voids in bone substance are a frequent concomitant of gross compound fractures, and particularly those resulting from gunshot wounds, high explosives or land mines in warfare Their management, as indicated above, depends to a large degree upon the coexistent degree of soft tissue involvement (see Chaps 28 and 29, 'Upper Extremities" and 'Lower Extremities")

COMPLEX WOUNDS

Thus far original repair has been discussed in terms of individual tissues With the exception of skin wounds, all others are of a more complex nature They involve the application of the aforementioned principles of original repair in compound form depending upon the kind and the number of tissues injured

A complex wound is one which clinically involves the general welfare of the patient anatomically more than one tissue surgically is usually a contaminated and frequently infected wound technically dictates more than simple primary approximation and functionally makes the prognosis as to total rehabilitation of the part a guarded one (Figs 98 and 99)

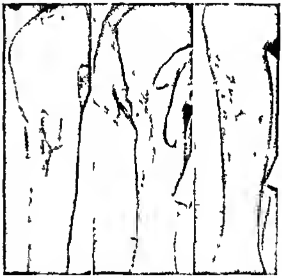


Fig 100 (*Left*) Injury similar to Figure 98, without benefit of 'biologic dressing ' Note depth of scar Scar and granulating center were excised, and deep tissues were repaired with the exception of bone A graftless local tissue repair was planned (*Center*) Same case Repair 8 weeks postoperative Case ready for bone grafting of tibia Note amount of postoperative tissue relaxation, which is often a questionable attainment without grafting, but not impossible with careful planning and atraumatic surgery (*Right*) Same case, 10 weeks after satisfactory bone graftings Note good leg contour and absence of scarring

FIG. 101. (*Top*) Results of late closure (after tenth day). Note scarring, tissue retraction and derangement. Contrast with Figure 18. (*Bottom, left*) Results of late closure (after tenth day) of deep injury to left arm. Note scarring and tissue retraction. (*Bottom, right*) Results of late closure (after tenth day). Note scarring, tissue retractions and joint derangements.

If the experiences of World War II have borne any fruit of consequence it is that the treatment of all such wounds is at least a two phase procedure whether the injury is accompanied by an open fracture or not This is unavoidable because a complex wound involves all gradations of soft tissue injury such as muscles tendons nerves *blood vessels and bone beside the extraneous* component of contamination Insofar as these are governed by individual biologic prevention of infection are of paramount import This was discussed in the beginning of this chapter

The next or as Churchill calls it the reparative phase of the surgery (Fig 100) consists of the removal of large foreign bodies the primary repair of nerves tendons muscle fascia final reduction of fractures *and occasionally major vascular re*pair This is the essential phase of original repair

FIG 102A Late repair by wound excision and dermoplasty (Pick s technic) Delineation of excision Note x ray film pattern of area of excision held above and at right angles to wound (cf Fig 102F)

differentials of healing and the effects of repair upon them multistage reparative intervention may be unavoidable In war injuries it is the rule rather than the exception

The first or initial phase of the surgery consists of the evaluation of the quantitative as well as the qualitative nature of the wound and all such general measures as are consistent with and necessary to the preservation of the patient s life The avoidance of the development of shock and the establishment of ideal conditions for healing with

Unless possible in the first four to six hours after injury this period on the basis of clinical experience alone begins about one hundred hours after the original trauma and ends for all practical purposes after the two hundredth hour following the original injury This time interval incidentally coincides with certain physiologic laws obedience to which in World War II has resulted in greater clinical gains and better functional rehabilitation This phase of original repair terminates with the closure of the skin It must not be confused with so called

secondary or delayed suture because the latter applies only to the closure of the covering tissue of the body rather than to the functional perspective of exact anatomic is almost entirely dependent upon exact anatomic repair whether this takes the form of complete original repair or the less promising forms of late repair Hence

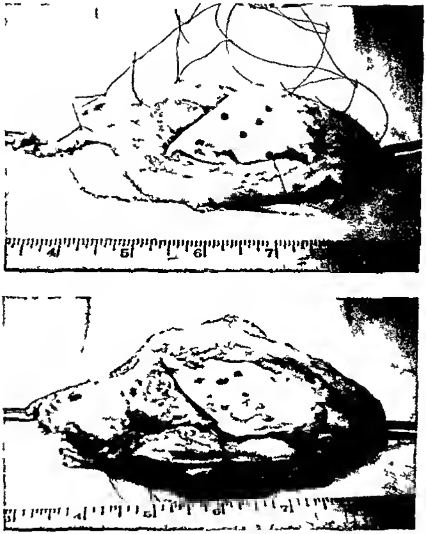


FIG 102B Late repair by wound excision and dermoplasty (*Continued*) (*Top*) External aspect of tissue excised en bloc The suture loops at top held aseptic bundle dressing during surgery (See Fig 43D) (*Bottom*) Underside of excised tissue Note drill holes in tibial bone done elsewhere This attempt at regranulation of wound failed

wound repair In other words the early closure of a wound whether by direct skin approximation or free grafting may expedite healing but physical closure alone does not guarantee adequate function The latter primary or delayed closure and original repair are never synonymous in the mind of the plastic surgeon (Fig 101)

Churchill has reduced the over all management of complex war wounds to the

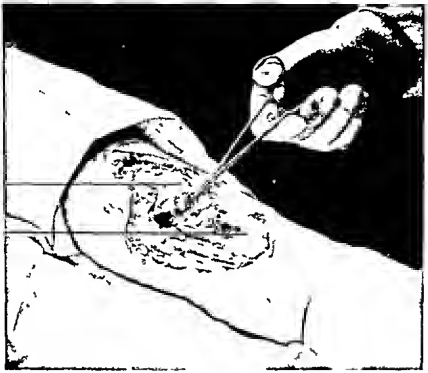


FIG 102C Late repair by wound excision and dermoplasty (*Continued*) Surgical defect following excision Note depth of wound and bone defect Wound recesses must be ablated by collateral soft tissue before superficial coverage (see Fig 139)

FIG 102D Late repair by wound excision and dermoplasty (*Continued*) Closure accomplished via bipedicle flap from lateral side of leg (see Chap 29)

following principles, which it would be difficult to augment

1 When the initial surgery (debridement) has been completed and the wound has been protected from subsequent contamination by an occlusive dressing and adequate splinting the optimal time for closure is the fourth postoperative day At this time muscles and fascial planes may be sutured with catgut, cotton or silk, and closure of the skin defect may be aided by the advancement or rotation of flaps or the application of a split thickness graft

2 As the time interval is increased beyond the fourth day, the feasibility of anatomic layer closure diminishes and there is a steadily increasing number of cases in which closure must be performed by single sutures passing through all layers

3 On or about the tenth day it will be found necessary to undercut the cutaneous margins, with or without the removal of surface granulation tissue, to obtain skin approximation The incidence of kindly healing will be appreciably lessened, and the ultimate scar will tend to spread

4 Again as the time interval is extended beyond the fourth day, there will be found an

increasing indication completely to excise the wound before suture thus to restore flexibility and permit layer closure This procedure is limited to wounds in anatomic regions where additional loss of tissue will not interfere with the ultimate functional or esthetic result In very late wounds (3 weeks to 6 months) complete wound excision is an essential prelude to closure by suture and may be necessary or advisable preceding skin grafting (*Fig 102*)

5 When the initial surgery (debridement) has not been complete, and devitalized tissue remains in the wound, a purulent exudate, at times associated with a foul odor, will be apparent by the fourth day Under these circumstances, the residual necrotic tissue may be excised and the wound closed immediately or, following excision, the wound again may be left open and closure undertaken when it is certain that all dead tissue has been removed and invasive infection is not to be reckoned with

6 When invasive infection is present free drainage is established and tissue devitalized by the infection or by the original trauma is excised The interval, before closure may be attempted, varies with the severity and extent of the infection, but usually falls within the 10 day period following the operation *

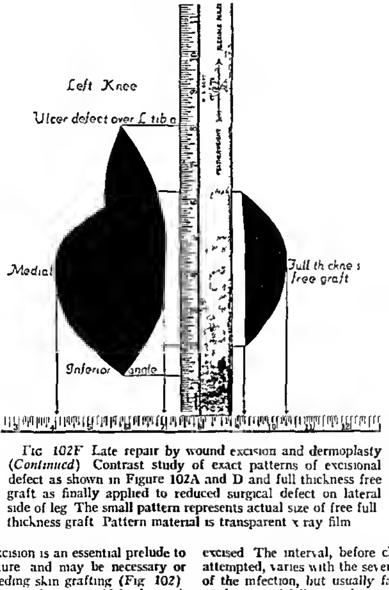


FIG 102F Late repair by wound excision and dermoplasty (*Continued*) Contrast study of exact patterns of excisional defect as shown in Figure 102A and D and full thickness free graft as finally applied to reduced surgical defect on lateral side of leg The small pattern represents actual size of free full thickness graft Pattern material is transparent x ray film

The ideal of original repair is a good functional result Good functional results can be attained only by a true physiologic

* Churchill E D., The American surgeon, U.S., Surg., Gynec & Obst. 84 535, 1947

perspective in surgery It should be obvious to the student, as well as to the surgeon, that the original repair of an extensive wound becomes an important if not special surgical program indispensable to the intelligent prosecution of the potentialities of modern surgery and the adequate functional rehabilitation of the patient as a whole Its timing and prosecution under different conditions are a test of fine surgical judgment

BIBLIOGRAPHY

von Axhausen Die moderne Wundbehandlung Fortsch Med 28 69 2 842 846 1910

Baxter H Entin M A and More R H Experimental and clinical studies of reduced temperatures in injury and repair plast & Reconstruct Surg 3 11 33 1948

Beattie J Metabolic disturbances after injury Brit M J 2 813 1947

Beck E C Adhesive plaster method for the rapid regeneration of skin over granulating wounds Ann Surg March 1919 p 291

Berman J K Peterson L Butler J The treatment of burn shock with continuous hypodermoclysis of physiological saline solution into the burned area Surg Gynec & Obst 78 3 1944

Blair V I Relation of the early care to the final outcome of major face wounds in war surgery Mil Surgeon 92 12 16 1943

Blair V P and Byars L T The desirability of early proper treatment of face injuries Texas State J Med 38 533 1943

Bothe R T and Davenport H A Reaction of bone to metals Surg Gynec & Obst 74 231 1942

Bowers W F Chlorophyll in wound healing and suppurative disease Am J Surg 73 37 1947

Brown C I First treatment of open wounds etc New Mexico Med Jour 7 109 113 1911

Brown J B and Byars L T Spontaneous and surgical covering of raw surfaces Journal Lancet 60 03 1940

Burian F Fysiologicke Operovani Kohtis karna Tiyjus V I raze 55 2145 2150 1945

Carrell A The treatment of wounds J A M A 55 2148 1910

Chouke K S and Whitehead R W Wound healing with especial reference to muscle and fascia repair Surgery 17 194 1945

Converse J M Early and late treatment of gunshot wounds of the jaws in French battle casualties in North Africa and Italy J Oral Surg 3 112 1945

Cordier G et Demirleau J L utilisation du plasma ou serum animal chez l homme plasma ou serum universel detoxique Presse med 54 883 1946

Co Tui F W The value of protein and its chemical components (amino acids) in surgical repair Bull New York Acad Med (2nd series) 21 631 1945

Davis H H Possible etiologic relationship between a single trauma and malignant tumor Am J Surg (N S) 51 641 652 1941

Davis J S and Kitlowski E A The theory and practical use of the Z incision for the relief of scar contractures Ann Surg 109 1001 1939

Estes W L Jr Non penetrating trauma of the abdomen South Surgeon 10 427 1941

Farmer A W Whole Skin Removal and Replacement An operative procedure of value for the salvage of skin undermined by trauma or for the recovering of areas from which resection of extensive subcutaneous tissue has been necessary Surg Clin of North America Oct 1943 pp 1440 1447

Farris J M and Jones T B Some observations on wound healing a clinical study with a note on topical chemotherapy and secondary closure Surg Gynec & Obst 84 205 212 194

Fruchaud H Treatment of recent war wounds French and Spanish methods Lancet 1 725 1942

Gallagher J L Initial treatment of traumatic wounds Am J Surg (N S) 57 231 1942

Gilcreest E L Progress of the surgery of trauma presidential address Am J Surg (N S) 51 553 572 1941

Goldberg D I The stimulation of wound healing by embryonal tissue Am Rev Soviet Med 2 225 229 1945

Goodman J H J Meehan J and Frankel R Capillary permeability in relation to acute anoxia and to venous oxygen saturation J Clin Investigation 26 1119 1947

Guilbert H D Suturing infected wounds of the face J Internat Coll Surgeons 7 44 48 1944

Gurd F B Surplus parts of the skeleton A recommendation for the excision of certain portions as a means of shortening the period of disability following trauma Am J Surg 74 05 720 1947

Gurd F B and McKim L H Use of B I P P and liquid paraffin in the treatment of wounds Am J Surg (N S) 51 554 1941

Harvey E N Butler E G McMillen J H

and Puckett, W O Mechanism of wounding, War Med. 8 91, 1945

Hayden, R Present Treatment of wounds and burns J Internat Coll Surgeons 7 179-190 1944

Hercher F Zuckerbehandlung eiternder und verunreinigter Wunden Munchen med Wchnschr 63 333 1916

Herrmann, L G Management of injuries to large blood vessels in wounds of violence, Am J Surg 74 560 575 1947

Hertzler, A E Wound Healing, Kansas, Halstead, 1944

Hurley V The surgical lessons of the last five years of war and their application to post war surgical practice Australian & New Zealand J Surg 15 235-248 1946

Johns T N P A comparison of suture and nonsuture methods for the anastomosis of veins Surg Gynec & Obst 84 939 942 1947

Jones H W, Falor W H, and Burbank C B Five hundred and twenty four abdominal wounds on the western front Bull Johns Hopkins Hosp *79 283, 1946*

Kapel, O Cat Bite—Pasteurellosis—Halisteresis Acta Chir Scandinav 95 Fasc 1 II 27 30 1947

Kazanjian V H Early treatment of gunshot wounds of the face and jaw, Surg 15 22 1944

——— Primary care of injuries of the face and jaws Surg Gynec & Obst 72 431 1941

——— Early suturing of wounds of the face J A M A March 1, 1919 p 626

Kirby, D B Emergency ophthalmic surgery, New York State J Med 47 143-150 1947

Kreuscher P H Treatment of fresh wounds Am J Surg (N S) 51 No 3 1941

Lebedenko, V V Observations on field surgery J Internat Coll Surgeons 7 573 583, 1944

Lindquist, J L Problems of trauma, J Michigan M Soc 45 1353, 1946

Lumiere, A A propos des lois de la cicatrisation Rev de chir 37 549 565, 1918

Lustig B, Goldfarb A R, and Adlersberg, D Distribution of proteoses and peptones after intravenous injection Proc Soc Exper Biol & Med 58 120-142, 1946

McDougal, W Effects of parenteral saline solution on wound healing, Am J Surg 71 312, 1946

MacFee, W F Arterial anastomosis in War Wounds of the Extremities Surg Clin North America, Philadelphia and London Saunders, (N Y Number) 1943 pp 351 359

McMaster P. E Human bite infections, Am J Surg (N S) 45 60-65, 1939

Mandl F Adult tissue extracts in promotion of wound healing J Internat Coll Surgeons 7 34 43 1944

Matthews D N The Surgery of Repair, Blackwell Scientif Pub Ltd 1943

Miller H and Winfield J M Human bites of the hand *Surg Gynec & Obst 74 153 1942*

Moorhead J J Survey of traumatic surgery Am J Surg 74 233 240 1947

Morrison, J T Hartley and Bashford Delayed primary suture of wounds Lancet 1 534 1918

New G B Immediate care of automobile injuries to the face at the scene of the accident, Proc Staff Meet Mayo Clin 15 728 1940

O Connor G B Immediate management of amputations of the hands, feet and digits California & West Med 66 11 14 1947

Owens Neal Surgical treatment of burns—use of pressure dressings Transactions 13th Ann Meet, Am Soc of Plast & Reconstruct Surg *2 226 233 1947*

Padgett E C Severe injuries of the face and jaws Am J Surg (N S) 51 829 1941

Phemister D B Contributions of animal experimentation to the treatment of surgical shock Surg Gynec & Obst 86 No 4 1948

Pulaski E J and Meleney F L and Spaeth W L C Bacterial flora of acute traumatic wounds Surg Gynec & Obst 72 982 988, 1941

Ranzi E Zur Frage der primaren Okklusion der Schluss wunde durch Naht Wien klin Wchnschr 28 555 556 1915

Reah, T G Basal cell carcinoma at site of trauma *Brit M J 1 p 412 1947*

Ritter, H H, and Kaye B B Trauma to the abdomen Am J Surg 71 760 1946

Rosenfeld L Delayed suture of war wounds Surg 21 200, 1947

Sandblom, P The effect of injury on wound healing Ann Surg 129 305 1949

Schumm H C First aid treatment of fractures Wisconsin M J 40 1061 1941

Seelig M G Compensation in one trauma cancer, J Missouri M A 44 27-32 1947

Shipley, E R, and Dodd, M C *Clinical observations on furacin soluble dressing in the treatment of surface infections*, Surg, Gynec & *Obst 84 366 372, 1947*

Simeone, F A The Anastomosis of Severed Arteries by a Nonsuture Method Surg Clin of North America, Mass Gen Hosp Number, Philadelphia Saunders 1947

Slobe, F W The treatment of soft tissue injuries Illinois M J 83 21-26 1943

Spaeth, E B The immediate and late treatment

of injuries about the orbit Presentation with case reports, Surg, Gynec & Obst 72 453, 1941

Speidel, W C The zero hour in the treatment of trauma An original hypothesis, Am J Surg 74 576 578 1947

Sperling L, Bosher L H, and Zimmerman, H Surgery of war wounds of the abdomen A review of one hundred consecutive patients, operated upon by a single surgical team working in forward areas in the European Theatre of operations Surgery 21 258, 1947

Stewart J D Postoperative shock to hemolytic streptococcus wound infection, Surgery 9 204 211 1941

Straatsma C R Surgical technique helpful in obtaining fine scars, Plast & Reconstruct Surg 2 21-24, 1947

Straith, C L Management of facial injuries caused by motor accidents J A M A 108 101, 1937

——— Treatment of fascial wounds due to explosions J Michigan M Soc 41 484, 1942

Sweeney H M The effect of carbon and radiation on wound healing Surgery 3 127, 1937

Tanner, F H Some aspects of traumatic pathology Nebraska M J 32 69, 1947

Thomson, J L Ritchie W P French L A, and Wrork D W Plan for the care of peripheral nerve injuries overseas, Arch Surg 52 557, 1946

Tompkins, C A, Crook, G W, Haynes, E, and Winters, M • Pectin in the treatment of various types of wounds, Surg, Gynec & Obst 72 222, 1941

Trueman, K R Early postoperative wound disruption Canad M A J 57 550, 1947

Trusler, H M, Egbert, H L, and Williams, H S Burn shock The question of water intoxication as a complicating factor blood chemical studies and report of an extensive burn treated by repeated transfusions of blood and blood plasma J A M A 113 No 25, 1939

Vaughan, R T Primary suture of war wounds, Internat Abstr Surg April, 1919, p 281

Waldapfel, R Classic and Other Types of Tracheotomy, Arch Otolaryng 45 446, 1947

Wagner, J H Plastic surgery in acute trauma, Am J Surg 74 322-327, 1947

Wolfer, J A, Farmer, C J, Carroll, W W, and Manshardt, D O An experimental study in wound healing in vitamin C depleted human subjects, Surg, Gynec & Obst 84 No 1, 1947

Woolf, A E M Tissue infiltration by cholesterol as a result of trauma, Brit J Surg 29 327-329, 1942

Young, F The care of soft tissue injuries New York State J Med 43 1521 1526, 1943

16

Skin Grafts and Grafting

The idea of the transfer of human tissue for the purpose of reconstruction of bodily injuries is one of the oldest in the history of surgery Theoretically at least any viable tissue should be amenable to transfer from one part of the body to another or possibly even from one individual to another—the latter for at least temporary survival This transfer from one individual to another has had limited success in the form of blood transfusions corneal transplants and transfer of skin (See Homografts ' this Chapter, and Arterial Grafts,' Chapter 17)

In spite of the age old interest in the transfer of human tissues and the therapeutic advances garnered in the last two decades, tissue grafting as a whole remains one of the great problems in surgery This is true not only from a biologic but also from a clinical standpoint The universal acceptance of the therapeutic value of grafting must not prejudice the student to the legion of unsolved problems remaining First among these is the seemingly simple question as to whether or not a free graft is always a good graft from the standpoint of reconstruction, or whether or not it is even a necessity

Grafting can be abused in the same way as any other form of therapeusis Where a graft is obviously necessary, the choice of the exact type of graft is the second problem Any type of graft for any condition is as inconsistent with good surgery, as using any kind of cathartic for any form of constipation The problems posed by tissue defects and their repair by adequate grafting are manifold and call for much experience and mature judgment, because grafts of different types have their individual and specific therapeutic indications

Classes of Grafts Such tissue as is given *and received by an individual onto himself* is known as an autograft Any tissue donated by one individual and transferred on to another is a homograft A blood transfusion is always a form of homografting It is at one and the same time a free graft

Nature of Grafts Organically, grafts are referred to as skin grafts, bone grafts cartilage grafts fascial grafts and so on, depending upon their morphologic character

Categories of Grafts All tissue grafts may be divided into two great categories the free graft and the pedicle graft This alludes to two different basic types of transfer A free graft is tissue which in one way or another, through deliberate surgical effort, at once loses complete contact with its source and becomes an integral part of a recipient site A pedicle graft is a tissue which ultimately reaches its destination or recipient site, through methods of gradual transfer, but always maintains at some point and at all stages vascular communion with its immediate place of origin

FREE GRAFTS

The modern development of skin grafting at once stands out as one of the most formidable events in surgery and at the same time represents a contribution to therapeusis at least equal in import to the recent developments in chemotherapy

Historical

Historically, skin grafting is textually measured from the time of one Branca, a

Fig. 103 (*Top*) The Davis pinch graft differs from the conventional type in that the former as shown in the illustration is cut so as to have a full thickness core and an epidermic periphery The transition centripetally is from full thickness skin to epidermis in almost perfect geometric gradation (*Bottom*) Misuse and limitations of pinch graft The defect is located on the back of the leg Its size and depth call for a thick split graft Note ridges of scar tissue surrounding pinch grafts, resulting in poor functional as well as esthetic result Donor site for so many pinch grafts also remains ruined for further use

Wound Doctor' of Catania, who lived in 1442 Through information coming out of India, he practiced "grafting' by the sliding in of pedicled tissues adjacent to a defect, a method contemporarily known as the Indian method of Repair," and also referred to as the 'French method" Not until 1597, when Tagliacozzi described the use of tissues pedicled on an extremity, specifically the arm, now referred to as the Italian method of grafting, can there be said to have taken place the rebirth of plastic surgery Both methods, naturally, due to lack of asepsis and proper armamentaria, were practiced by only a few and eventually fell into disrepute

Skin grafting, particularly as it is commonly thought of in America, should be said to have had its beginning with the Swiss surgeon Reverdin, who in 1869 reported his experiences in a case, in which he used what he termed the '*greffe épidermique*" Reverdin reported upon a patient who had lost the skin of his thumb, to which were transferred two little morsels of epidermis Each of these was a thin bit of skin about two millimeters square and was laid upon the granulating surface of the injured finger Such was the birth of what we now refer to as epidermic, epithelial, or thin razor grafting

In 1872 Ollier, and in 1874 Thiersch, pointed out certain objections to Reverdin's method, such as the protracted healing time, the scarring of the graft, its loss under weight bearing, its tendency to contraction and its cosmetic shortcomings Both Ollier and Thiersch had independently found greater advantages in using thicker skin As Ollier expressed it, Instead of using bits of epidermis, as Reverdin does, I use large grafts, four, six or eight centimeters square, including not only the epithelium, but part of the derma That in reality may be looked upon as the birth of the so called split graft' of Blair and Brown of St Louis

Soon of course, certain shortcomings of even this more substantial piece of skin of Ollier and Thiersch made themselves ap-

parent and surgeons again reverted to the second Italian method of grafting now referred to by us as the *full thickness skin graft*

Wolfe of Glasgow in 1875 induced resurgence of the full thickness skin graft by constructing a successful lower lid But within a period of ten years the virtues of even the full thickness graft seemed to have been exhausted Its difficulties more than its shortcomings led to Nass s redescription of the Indian and the first Italian operations which thus far have stood the test of time

Since that period not much of the fundamental has been added to skin grafting The recent additions for the most part have been amplifications and elaborations of the ideas of Branca Tagliacozzi Reverdin Ollier Thiersch Wolfe and others These new additions are eminently represented by the *tube graft* first used by Filatov Burian and Sir Harold Gillies the epithelial inlay of Waldron Esser and the essentially mechanical contributions made by the American plastic surgeons Blair Brown Padgett Caltegirone and others in designing instruments for the mobilizations of skin grafts All else that has been contributed to skin grafting since the time of the pioneers may better be said to constitute amplification and elaboration rather than discovery but these amplifications mark its evolution

With the invention of the various dermatomes for the most part contributions of America to the art skin grafting has been placed on a more scientific and accurate basis

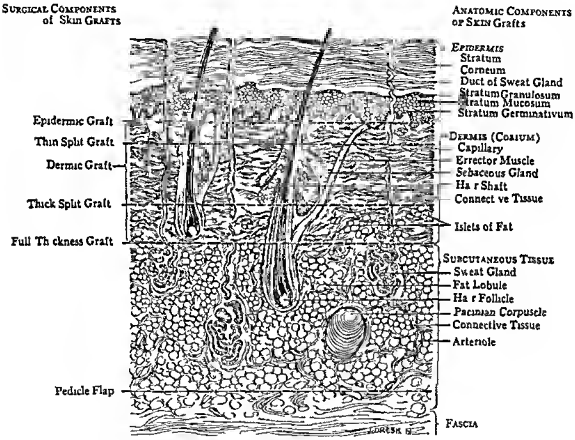


FIG 104A Micro-anatomic levels of grafts

Types of Skin Grafts

Free skin grafts may be divided into five types the epidermic the split (thick or thin) the full thickness the dermic and the pinch (Davis) graft (Fig 103)

Anatomic physiologic Considerations The many names attached to skin grafts are almost legion When all these are reduced to a common denominator they can as indicated be classified under three major types

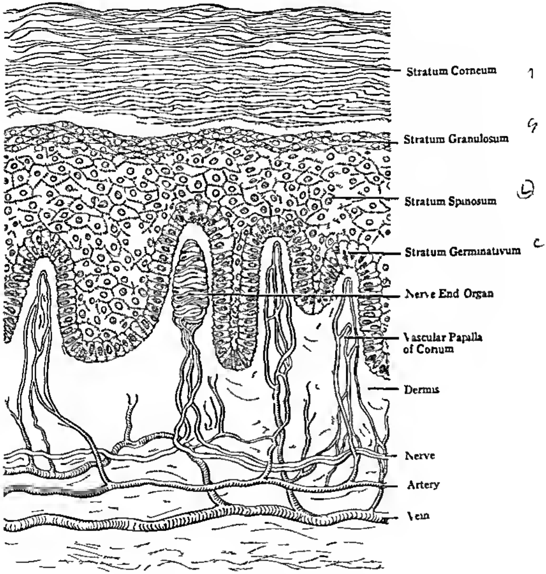


Fig 104B Micro anatomic levels of split graft

The pedicle grafts may be divided into single peduncle grafts multiple peduncle grafts and the tubed pedicle To these three may be added the pillowed pedicle (see author s pin cushioned flap Fig 9)

the epidermic graft the split graft (thick or thin) and the full thickness graft (Fig 104) To these may be added two others which differ microscopically and clinically as well as therapeutically from the other

three They are the dermic graft and the pinch graft, which will be discussed presently The first three "types" of skin grafts only more or less represent the Reverdin, the Ollier (or Thiersch) and the Wolfe graft, because, strictly speaking neither Reverdin nor Ollier thought of their grafts in terms of an accurate anatomic third dimension and its physiologic implications, so much as in terms of size Although both recognized that the virtue of the skin graft increases with its thickness, they nevertheless did not evaluate them in terms of microscopic content

The necessity for understanding the skin graft in terms of micro anatomic values, rather than simple geometric thickness, is becoming more and more apparent There is a definite relationship between *anatomic* thickness of a skin graft and its *physiologic* experiences, post transfer Other things being equal, the clinical results vary accordingly Since the physiologic experiences of a graft are dependent on its microscopic rather than its geometric thickness and size it is not logical to expect a split graft of 15/1,000 of an inch from under the arm and one of the same thickness from the buttocks to produce identical clinical results A split graft of that thickness from the buttock, notorious for the volume of its epidermis, never can yield the clinical results of a graft of the same thickness taken from the underarm where the epidermic layers are very thin A graft of 15/1,000 inch taken from the underarm would be a thick split graft containing much of the derma In the case of the buttock skin one is employing essentially epidermis, the outer layers of which have for the most part reached a decadent biologic stage Hence, the ultimate clinical results measured in months or years should be and are different

Epidermic Grafts For purposes of scientific accuracy, an epidermic graft should be one which never reaches in microscopic thickness beyond the stratum germinativum of the skin Anything more than that in

FIG 105 Thin split graft applied to a poor bed with high degree of success Patient suffered with infected ulceration of popliteal region but was not equal to extensive excision, because of acute coronary attack Ulcer was poulticed with saline compresses for 5 days and the graft was basted in under local analgesia

microscopic thickness, but not yet containing all of the anatomic and physiologic elements of the skin, may well be designated as a split graft' A full thickness graft would be one containing all of the microscopic layers as well as all of the physiologic elements of the skin It then becomes obvious that the geometric thickness of a graft would be dictated by the part of the body from which the skin was taken The clinical application of such a yardstick would lead to greater uniformity of results and better understanding of functional consequences

The primary and almost exclusive function of the epidermic graft is that of a

Fig 106 Lower extremity of patient severely burned (58 per cent) covered by homo grafts After similar coverage of both legs the patient responded for the first time from a condition of hopeless extremis within 18 hours Note difference in color and quality of the various grafts due to the fact that they came from four different donors (*Insert*) Diagrammatic representation of placement of Padgett split grafts on exten sively burned extremity Grafts 8 10 and 12 were paired grafts and came from two different donors one of whom also contributed graft 4 Donor No 3 contributed grafts 1 2 3 and 6 Donor No 4 contributed grafts 5 7 9 and 11 Note that in so far as the emergency permitted grafts were placed so as to mimic Langers lines of tension par ticularly about the knee joint

temporary biologic dressing Its reconstruc tive and functional value is exceedingly small with the possible exception of the corneal transplants Because of its ability to live on nothing but tissue juices it may be placed on almost any type of open wound even a relatively infected one with considerable hope of success (Fig 105)

Split Grafts Though the art of splitting skin has been an immense contribution to surgery the split graft nevertheless remains in the eyes of nature a substitute for true skin Particularly is it true of the Ollier Thiersch variety or thin split graft Both the epidermic and the split graft are the product of man s ingenuity Though they are practically indispensable in a large number of selected cases they are biologi cally incomplete and hence physiologically inadequate

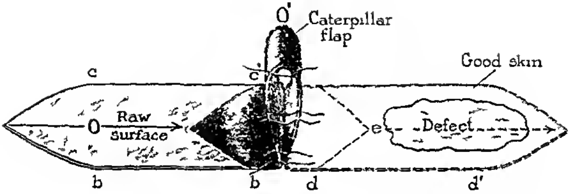
The epidermic and the split grafts are surgically indispensable even as the sulfa drugs penicillin and streptomycin are medi cally indispensable Their specific use in plastic surgery is to subserve the function of a permanent biologic dressing to expe dite the making of closed from open wounds (see Indications this chapter) When reason is superseded by ease of ap plication and by habit a surgical privilege may become a nuisance Hence it is that frequently one is forced to excise one kind of graft and replace it by another more in keeping with the functional demands of the injured part

Until a better evaluation and general ap preciation of the aforementioned principles is realized free skin grafting will be subject to abuse and misinterpretation

Full Thickness Grafts Nature knows only one kind of skin which is the skin of the micro anatomist and the physiol ogist It is the skin represented by the full thickness graft Hence when anything less is used as a graft than what actually con stitutes skin it should not be surprising to learn from experience that nature sooner or later steps in to compensate for that which is lacking by throwing in fibrous tissue hence the late subcutaneous contractures following thin split grafts (Fig 104 A)

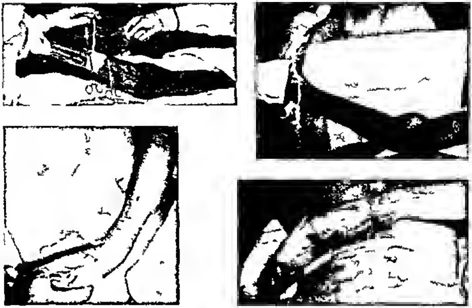
Dermic Grafts At this point it might be

PLATE 4



Mode of migration of so called caterpillar flap Pink area is the donor site Purple area denotes interim position of flap Blue area (including a b c) is the final position of migrated flap

PLATE 5



(*Top, left*) Severe third degree burn of the lower extremity in the process of being homografted The reasons for use of homografts in this case were that 58 per cent of patient s body was burnt, all else therapeutically reasonable and necessary had been done without adequate response to treatment The patient had gone into alternate periods of delirium and unconsciousness, temperature was 107 2 F, he was involuntary and in extremis, and the addition of surgical trauma attending mobilization of autografts could not be risked Note exposure of tibial periosteum and tendons Also observe quality of granulation tissue covering entire extremity (*Top, right*) Entire extremity, with the exception of sole of foot, homografted and at time of second dressing (19 days postoperatively) Note the minimal loss of the grafts in the region of the thigh and the medial aspect of the instep The difference in color of various sheet grafts is due to the fact that they came from four different donors The patient began improving clinically 10 hours after application of homografts and made a complete recovery, although donated grafts were thrown off by the body completely from both lower extremities in 5 weeks

(*Bottom, left*) Massive simple peduncle abdominal flap transferred to extensive defect of the forearm The small area of superficial necrosis in the center of the peduncle is the result of a stout tension suture employed to appose the lips of the donor site so as to reduce the raw area under the forearm (*Bottom, right*) The underside of abdominal flap and its attachment to the forearm Note the relatively extensive raw area of the flap exposed to all the exigencies and complications of an open wound Where a large number of cases must be attended, as during a war, this is an expeditious method of immediate closure of extensive wounds It is to be avoided where possible, because it is a septic form of surgery Where unavoidable, the exposed part of the flap should be covered by a thin split graft

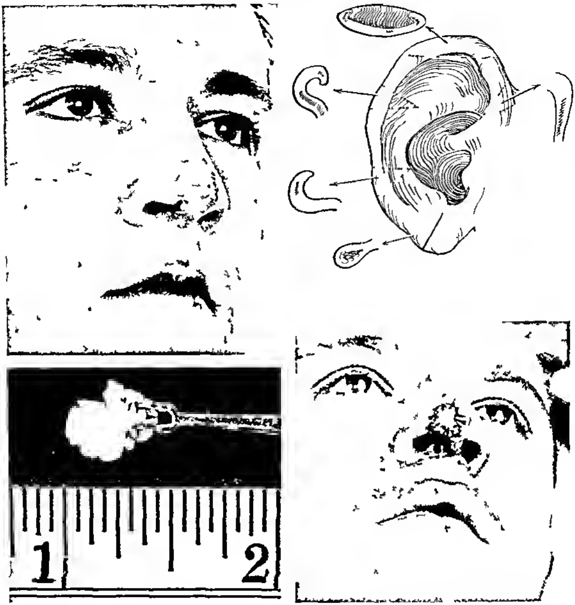


FIG 107 The composite free graft (*Top, left*) Scarred nasal tip and columella with traumatic cleft and subcutaneous tumor The entire right side of the tip and columella were excised (*Top, right*) Source and diagrammatic representation of composite grafts in general use (*Bottom left*) Underside of tumor (chondrolipoma) Tenaculum in columellar skin (*Bottom right*) Repair by composite graft from right ear

well to mention the dermic graft It contains only the elements constituting the derma or true skin (Fig 104) In other words it is skin minus its epidermic and deep fatty studded layer of derma It was first used by Lowe in 1912 It is obtained by cutting the epidermic layers from the skin and then excising the derma in any geometric size or pattern This graft can be used in place of fascia as suture material and as a buttress in filling out shallow depressions (Fig 10)

Dermic grafts are also used in the repair of large hernial openings instead of fascia

FIG 108A Direct transfer of massive single peduncle flaps (See Fig 25G and Plate 5) Where a large number of cases has to be expedited as in World War II recourse is sometimes had to open pedicle transfer of tissue It is an expeditious but relatively septic form of surgery to be avoided if possible

as suspension ribbons in facial paralysis in stage ligations of larger arteries in utero cervical suspensions as covering for muscle herniations and for reinforcement of unstable joints Their use in most of these conditions seems to be somewhat overrated

When using derma as buttress material in filling out depressions of contour no more than a once folded piece should be inserted since only such derma will survive as is in immediate and constant contact with circulation (Fig 10) The practice of packing derma into a pocket created for it is unwise because that part of the tissue created in the center of the pocket will liquefy or atrophy before any blood vessels get to it The most reliable procedure is to insert single or at most double sheets into a depression and keep repeating the procedure until the depression is corrected

It is categorically true of derma that it always must be placed into a field with good circulation or it will soften and disintegrate quite rapidly I have observed this frequently in cases of facial paralysis associated with poor circulation where derma was used as sling material It had to be replaced by fascia because the latter will survive where derma will not

Homografts Occasionally under war or catastrophic conditions homografts have to be used They are always used as free split grafts of from 0 008 to 0 012 in thickness in the knowledge that they are temporary biologic dressings of only life saving value and sooner or later they must be replaced by autografts when the patients general condition permits (Fig 106)

Permanent survival of full thickness homografts has been reported by Brown and Padgett but only in identical twins According to Loeb the reason the transplantation of tissue from one person to another is not successful is that there exists a unique and fundamental physiologic individuality in each one of which we as yet know little or nothing This makes the tissue of one person biologically foreign material to another

J Barrett Brown* succinctly summarizes our experiences with homografting in the following words

> Suggestions have been made to try to insure permanence of these grafts the best known of which is that the donor and recipient should be of the same blood group but there is no measurable value of this selection of donor skin either in the take of the graft or its survival Other methods have been something like desensitizations—injection of the recipient s blood around the graft site on the donor delaying the graft and exposing it to the recipient s serum and doing preliminary transplants to try to accustom the donor to the presence of foreign skin The method of Stone in the culture of donor parathyroids in the recipient s serum has so far not been reported successful in working with skin but may prove to be possible at least for the single element of epithelial cells The successful solution of this problem would be one of the major advances in reconstructive surgery but for the present the patient s own available skin must be depended upon By using thick split grafts (thick Ollier Thiersch grafts) in

* Surgery 1 558 1937

FIG 108B Direct transfer of massive single peduncle flaps (*Continued*) (*Top*) Shows raw undersurface of large abdominal flap exposed to at least saprophytic contamination (*Bottom*) Demonstrates difficulties in healing often encountered with direct massive flaps (see Plate 5)

all possible repairs one can usually find sufficient quantity of donor skin and by careful removal of the grafts the same donor site may be used as many as three to four times

I have employed massive homografts on several occasions as emergency therapeutics in hopelessly burnt patients who quite definitely survived only because of such treatment although the grafts as such did not The longest survival time of a massive homograft in my hands has been six and one half months

Functional Appraisal The decision to use a free graft perforce is an admission of relative therapeutic defeat Upon the premise that the best functional results can be realized in surgery only by proper anatomic reconstruction it becomes apparent that

the use of a tissue totally and at once severed from the body economy can be only a kind of substitute for physiologic surgery especially if that tissue is at one and the same time anatomically incomplete as is an epidermic or split graft Additionally the extravagant use of the free graft leads to a kind of surgical patchwork which one should avoid if at all possible Hence true surgical reconstruction can only be accomplished by the use of the free graft in selected cases

Organologic Considerations We too often forget that the skin is an organ quite as much as the liver the lung the kidney or the brain In fact it is by far the largest organ of the body To quote Leider

> An organ is defined as any part of the body having a special function The average weight of the human liver is from 1 200 to 1 600 Gm The average weight of the human brain is 1 360 Gm The average weight of the skin is between two and three times greater than either The weight of the skin cannot be derived exactly by dissection and the use of scales as can be done for the other organs but it can be computed The result of computation is approximate but since the answer is from double to treble the figures with which it is to be compared and since the margin of error is much less than twice or thrice the conclusion is valid

> The formulas and calculations for the weight of the skin are as follows

Area of skin in sq cm	=	(Body weight in kg) 0 425 X (Height in cm) 0 725 X 71 84
Volume of skin in cc	=	Area of skin in sq cm X thickness in cm
Weight of skin in Gm	=	Volume in cc X specific gravity of skin ‡

‡ Leider M J A M A 134 1565 1947

Solving these simple equations with use of average values yields results of these magnitudes

Area of the human skin	=	16 000 to 18 500 sq cm
Volume of the human skin	=	2 400 to 2 800 cc
Weight of the human skin	=	3 000 to 3 500 Gm

The above calculations are in contrast with those of Muchow to the extent of about 150 per cent (12 lbs) Leider accounts for the discrepancy as follows

A frequently quoted figure on the weight of the skin is 16 per cent of the body weight of an adult This estimate derives from a report by Muchow* and is cited by MacKenna† It was obtained by weighing dissected specimens which included the entire subcutaneous fat Dermatologically the panniculus is not considered a part of the skin but only so much fat as includes the deepest coil glands constituting the hypoderm Thus the discrepancy between my calculation of the weight of the skin as about 8 pounds and his figure, of about 22 pounds is explained §

Insofar as nature controls the physiology and the economy of organs she in the same way controls the destinies of parts of organs when they are used as grafts including skin Nature also never fails to register the *consequences of radical injury of an organ* as that injury is related to the organism as a whole Therefore, it is not only a surgical tragedy when much of the skin is lost at one time as in an extensive burn but a physiologic mistake and poor clinical judgment to deplete further the integrity of the body economy by indulging in excessive skin grafting under such circumstances

Physiologically it should be and clinically it becomes quite apparent that superimposition of skin loss through grafting upon extensive skin loss through burning leads to more or less permanent disturbance in the physiology of the organism The thicker the

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* Tabul b ol 2 468 1925

† MacKenna R M B Modern Trends in Dermatology New York Hoeber 1948 p 45

§ M Leider Personal correspondence

CHART 4 CRITICAL EVALUAT

SIMPLE (*Cutaneou*

Type of Graft	Indications	Anesthetic	Min No of Surg Innings Necessary for Repair	Min Days Necessary to Complete Repair	Type of Surgery	Splinting	Complic. Graft	Donor Site
EPIDERMIC	1 First aid closure of fresh clean wounds 2 Temp biol dressing 3 To stimulate epithel 4 Superficial ulcers 5 Grafting of relatively contaminated wounds	Gen. or Refrig or I V	1	8	Open	Min	1	3
THIN SPLIT	1 Perm biol. dressing 2 Lining of rigid cavities 3 Treatment of extensive (30%+) burns 4 Lining bone cavities	Gen or Sp.	1	10	Open	Opt	2	3.5
THICK SPLIT	1 Perm resurfacing 2 Repair of healed or deep burns 3 Adequate grafting 4 Grafting of working surfaces viz., dorsum of hand 5 Treatment of scars 6 Avulsion of scalp	Gen or Sp	1	19	Open	Max	3	4
FULL THICKNESS	1 Reconstr of full thick losses, with ideal bed 2 Palm of hand 3 Face injuries 4 Avulsion of scalp	Loc or Gen	1	21	Closed	Max	.3	5
PINCH (Davis)	1 Small ulcerations 2 Small defects in full thick. graft 3 Stim epithelialization	Loc or Sp	2 3	20	Open	Max	7	10
DERMIC	1 Correct shallow depressions 2 Diastases 3 Hernias (repair) 4 Suture material 5 Suspension material	Loc	1 2	12	Closed	Opt	.5	2
HOMOGRAFT	1 Livesaving choice in extensive third-degree burns only 2 Skin losses in identical twins	Patient None Donor Gen *or Sp*	1	50	Open	Opt	.2	100
								COMPOUND (*Cellulocut*
SINGLE PEDUNCLE FLAP (Italian)	1 Extensive complex defects of extremities 2 Comp loss palm or sole 3 Rhinoplasty etc.	Loc or Sp	4	50	Open	Max	—	14 5
TUBE (Dieffenbach) (Filatov) (Gillies)	1 Reconstructions remote to donor site 2 Extensive comp defects 3 Constr of anat parts	Gen or Sp	4	66	Closed	Opt	—	3.5
"PIN CUSHION" FLAP (Pick)	1 Same as single pedicle flap or tube	Gen or Sp	3	44	Closed	Opt.	—	1.5
DOUBLE PEDUNCLE FLAP (Celsus)	1 Adjacent compound defects	Loc or Sp	1	18	Closed	Min	—	1
ROTATING FLAP (French)	1 External defects of face, scalp penis, decubital ulcers cleft palate cheek etc	Loc or Sp	1	14	Closed	Min	—	1.5

KEY

I V = Intravenous
Refrig = Refrigeration

Sp = Spinal
Loc = Local

Max = Maxi
Min = Minim

ALUATION OF DERMOGRAFTS
taneous) GRAFTS

OMPLICATIONS (%)			TISSUE COST				ECONOMICS		RESULTS					
Donor Site	Pedicle	Late (All Incl)	Pedicle	Graft	Donor Site	Secondary	Hospital Time (Days)	Monetary Expense	Anatomic	Functional	Collateral Physiological	Esthetic	Psychological Implications (Influence on Patient Morale)	Clinical Rating (Percent)
3	—	81	—	Negl	Negl	Negl	8	Min	Poor	Fair	Fair	Poor	Negl	30
3.5	—	62	—	Min	Min	Negl	10	Min	Fair	Fair	Good	Fair	Negl.	60
4	—	11	—	Min	Opt	Negl	19	Opt	Good	Good	Exc.	Good	Negl	85
5	—	3.2	—	Min	Negl	Negl	21	Opt	Exc	Exc.	Exc	Exc	Negl	100
10	—	23	—	Opt	Max	Mod	20	Opt	Poor	Good	Good	Poor	Negl	50
2	—	7.2	—	Min	Mod	Min	6	Min	Good	Good	Good	Good	Negl	75
100	—	—	—	Max	0	Max.	73	Max	Poor	Fair	Poor	None	Pos Good	—
tubulocutaneous) GRAFTS														
14.5	17	5.9	Mod	—	Max	Mod	50	Max	Fair	Good	Fair	Good	Pos Poor	70
3.5	5	2	Max	—	Min	Min	35	Mod	Good	Exc	Good	Good	Opt. Fair	80
1.5	3	5	Mod	—	Mod	Mod	36	Mod	Good	Exc.	Good	Good	Opt Fair	85
1	1.5	1	Min	—	Negl	Min	18	Min	Exc	Exc	Exc	Exc	Negl	94
1.5	2	5	Negl	—	Min	Min	10	Min	Exc	Exc	Exc	Exc	Negl	100

KEY
= Maximal
= Minimal
Opt = Optimal
Mod = Moderate
Negl = Negligible
Exc = Excellent

grafts mobilized in such cases the more rapid and certain of course the eventual physiologic consequences Therefore, it has been my practice in extensively burnt patients who are otherwise in good general condition to autograft as soon as possible only the joint surfaces of the extremities rather than a whole extremity thereby guaranteeing function of a part without injuring the whole for the sake of appearance Where autografting is not feasible homografting is a temporary therapeutic rationalism to expedite physiologic rehabilitation and conservation of the organism

Corneal Epithelium One of the more recently exploited free grafts is the transplantation of the human cornea This is a form of *homotransplantation* In spite of what has been said as to negative survival of homotransplants Castroviejo Filatov Thomas and others feel that a successful transparent graft is not replaced by autogenous corneal tissue from the periphery of the grafted defect

Leopold and Adler attempted the transplantation of frozen dried cornea in 75 rabbits with the following conclusion Frozen dried corneal tissue can be transplanted to normal rabbit eyes without an unusual host reaction However not one of the 59 takes with frozen dried cornea were transparent at any time during the six months of observation * In other words a physical success does not always guarantee a functional result

Others have reported sporadic functional results with transplantation of corneal epithelium but a positive stand in this matter would be premature because on the one hand there are many technical details to be considered in connection with transplantation which decidedly affect the physiologic life of any graft and, finally skin homografts have been known to survive as long as six months before complete discard by the host It is, therefore, too early

* Leopold I H and Adler F H Use of frozen dried cornea as transplant material Arch Ophth 37 268 276 1947

Fig 109A Methods of mobilizing free grafts Freehand cutting of epidermic and split grafts (*Top*) Showing position of Blair knife staging box (suction) and stabilizing medium (gauze-covered tongue depressor) held by assistant (*Center*) Epidermis being cut Note distance of staging (suction) box preceding knife (*Bottom*) Note almost transparent thinness of graft supported by hemostats to avoid curling on knife blade

FIG 109B Methods of mobilizing free grafts (*Continued*) Type of lesion well suited for epidermic or preferably thin split graft following debridement (See Plate 14)

to evaluate the ultimate status of corneal homo transplantation

Composite Free Grafts A composite graft is one consisting of more than skin covering and lining More specifically, it is usually applied to small through and through sections of the external ear Only sporadic attempts had been made at the transfer of auricular sections to defects of the nose with variable success F Konig was the first to use composite free grafts He employed the method during the first decade of the century Brown and Cannon popularized the method in 1946 Such sections or wedges are usually taken from the superior pole of the auricle to pattern, and carefully sutured in place cartilage to cartilage and skin to skin followed by adequate splinting Obviously only relatively small sections can be taken from the auricle up to about one half square inch but it is a rapid and simple method as compared with any other used in the repair of minor defects of the alae the nasal tip or the columella (Fig 107)

The transfer of composite free grafts from one ala to the other where gross difference of size exists or from one ear to the other, is likewise practicable

When failures occur they are usually due to lack of adequate approximation of the ear cartilage to the alar cartilages a fibrotic bed improper skin closure or inadequate splinting

PEDICLES

A pedicle is a calculated flap of tissue freed to only a predetermined extent from its place of origin—the donor site—for purposes of transfer to a recipient site The point at which the flap remains attached to its bed for reasons of circulation is its peduocle The remainder of the free tissue is the pedicle That portion of a flap which by transfer and imbedding becomes a permanent and integral part of a defect is a pedicle graft

Pedicles are of three kinds flaps tubes and pillows (see author s pin cushion ') They may all be of single, double or multiple peduncle type The difference between a flap and a tubed pedicle or pillowed pedicle is basic The difference between a tube ' and a pillow is one of form

The flap is an open type of surgical creation whereas the tube and the pillow are the result of a closed form of surgery They are tissue media of choice where reconstructions in depth are called for The selection

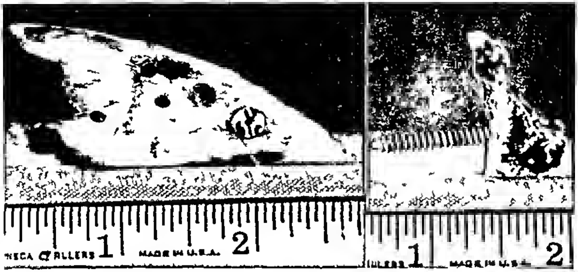


FIG 109C Methods of mobilizing free grafts (*Continued*) Amount of dead tibial bone removed which was followed by complete excision of old wound and free grafting pro tem (biologic dressing)

of one as against the other is not always simple It is often a matter of choice with the surgeon At other times it is a matter of expediency or as in war surgery a necessity (Fig 108) Hence much is said pro and con as to when to use a flap and when to use a tube

TUBE VS FLAP

The problem of choosing between the two becomes particularly important where large groups of patients have to be cared for as during World War II The occasion was a fertile opportunity for comparative study of the two methods of repair (Chart 4)

All methods of repair were employed the single pedicle flap sometimes referred to as the Italian method of repair the double pedicle flap the French sliding flap and the Filatov Gillies tube The source of the surgeon s training experience imagination and sometimes prejudice often determined the choice of method Many plastic surgeons stimulated by the apparent ease and efficacy of the single pedicle flap were tempted into repairing practically all defects in this way Others very early shied away from this method of repair for reasons to be given presently and favored the tube graft or other methods which had to be modified to suit the exigencies of war surgery

As a matter of fact therein lies the crux of the whole matter of repair and rehabilitation of the severely wounded These two methods—the flap and the tube—are the foundation of all radical plastic reconstruction yet they are basically two entirely different types of surgery

As mentioned earlier there was general preference for the use of the pedicle flap in World War II because it seemed to be easier of construction and management and was thought to give more expeditious results The tube graft was looked upon as a protracted method of repair which did not ultimately give any better results than the flap

One cannot entirely subscribe to either of the foregoing opinions The basic number of surgical innings necessary in the grafting of a given defect via the tube is four The same invariably holds true for the single pedicle flap Whereas an entire tube can be made in one stage it usually takes at least two surgical innings to complete a transferable flap of like dimensions since delay is unavoidable if adequate circulation

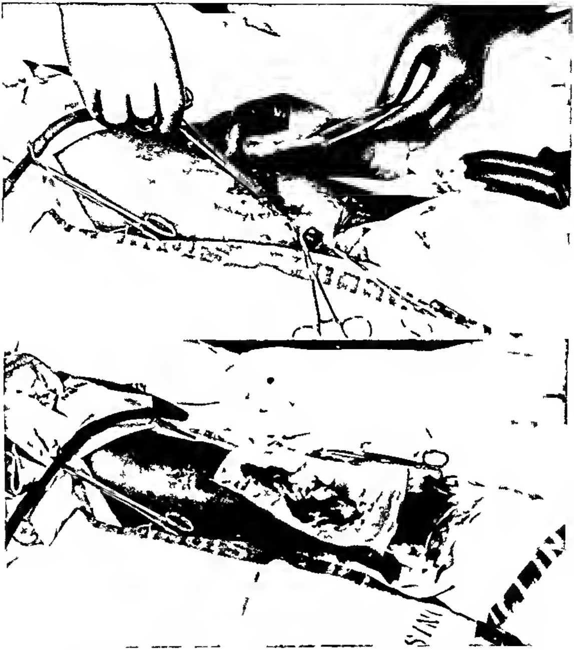


FIG 109D Methods of mobilizing free grafts (*Continued*) (*Top*) After thorough irrigation and drying graft is basted to wound edges (*Bottom*) Showing application of fiberglas gauze as proximal dressing over graft This is then superimposed by humid cotton gauze and bandaged

to the distal end is to be assured Only two of the three sides of a flap can safely be incised at first immediately followed by undermining Incision of the third boundary of the flap is a separate procedure usually done from ten days to three weeks after the first

True complete immediate transfer of a mass of single pedunculated tissue can be and has been done often but it entails con

siderable risk particularly in the lower extremity It most certainly cannot be held out as a promising routine in that location

Consequently the usual stage of transfer in the case of a single peduncle flap is the third surgical inning One more surgical step at least is necessary in order to complete the translation of the flap into a graft *by amputating it at its peduncle and* imbedding it into the surgical defect resulting from excision of the wound

In contrast with the foregoing the construction of the average *tube needs only one* surgical inning The transfer of it on the other hand necessitates two surgical steps because only one peduncle at a time can be cut *The* fourth step is taken up by the opening the spreading and the imbedding of the opened tube Hence in terms of the number of surgical procedures the tube does not differ from the flap

The next consideration is the time element involved in the two methods from preparation of the flap or the tube to the final grafting of the defect In the case of the tube three weeks *must* be allowed to elapse before the first peduncle can be transferred or the tube waltzed Four weeks should be allowed for the transfer of the second peduncle and two or three weeks is necessary before opening spreading and imbedding of the tube In other words be*fore the tube can be translated into a graft* an over all time of from nine to ten weeks is needed

In the case of the single peduncle flap two weeks *should* elapse between the initial stage of incision and the second stage of its complete delineation Two weeks is then necessary in the delay preceding its trans*fer to the site of* the defect *From* two to three weeks more must then elapse before sectioning of the peduncle and final imbedding of the graft This consumes a period *of from seven to eight weeks*

Hence on the basis of time alone the flap would have an advantage of about two weeks to recommend it But time never can be of primary concern in plastic surgery for the uncompromising essence of the grafting of defects is not mere physical re

Fig 109E Methods of mobilizing free grafts *(Continued)* Result *12* days postoperative A closed wound has been made out of an open one via a biologic *dressing*

FIG 109F Methods of mobilizing free grafts (*Continued*) (*Left*) Substitution of plywood boards (4 x 8 inches) for Blair suction boxes where the latter are not available Donor site right is the chest (*Right*) Cutting of graft begins as board preceding knife (staging medium) tenses and flattens donor area As soon as enough graft appears over knife to cover its blade assistant picks up free edge of graft with mosquito hemostats and elevates it just enough to keep it from catching or curling on the knife

construction but physiologic restitution An operation which fails in the reasonable accomplishment of the latter can well be put down as a surgical defeat At times this vital principle is rather difficult to establish in the mind of the student Mere physical reconstruction without physiologic restitution is not much better for subsequent entry for instance than a scarred defect per se

The number of surgical procedures necessary with either method being the same and the time differential being small and not of primary importance the factors which ultimately must determine the choice are the following

1 Which method is more nearly a physiologic procedure?

2 Which method comes closer to an ideal surgical procedure from the standpoint of asepsis tissue cost surgical exigency and ease of postoperative management?

3 Which method consistently gives better ultimate results?

Accepting the principle that closed surgery is the best surgery it is apparent that only the tube or the pillow meets this demand At no time in the entire process involving the use of the tube is there need for exposing raw surfaces to the unavoidable pathologic changes affecting all open wounds such as fibrosis lymph stasis infection and ultimate scarring The peduncle of a flap is at best a semiclosed wound even when carefully free grafted Should the free grafting be completely successful it is still a pseudophysiologic condition since there can be no normal physiologic communion between the adipose subcutaneous tissue of the flap and an epidermic dressing because it is an unnatural biologic relationship—as fibrosis between flap and free graft

The accusations here laid against the flap and in favor of the tube are borne out by many clinical evidences Some of these are the greater amount of subcutaneous fibrosis in the graft which originated as a flap the more frequent puckering of the flap graft postoperatively greater incidence of pigmentary changes in such a graft more protracted and prolonged starvation and consequent thinning of the graft Additionally there is greater frequency of postoperative infections in such flaps and a higher incidence of the transportation of latent infections to the recipient site Ultimately less consistent esthetic results are obtained with such flaps in contrast with the tube Care

fully kept statistics by the author show a much higher frequency of infected bone grafts insinuated under a flap graft in the hands of diverse operators, than under a tube graft The incidence is five to one over that of the tube

In general, it seems then that there should be little question as to which is the choice method, the single peduncle flap or the tube

THE DONOR SITE

The tissue selected for a graft should comply, if at all possible, with the following requirements

1 The tissue must be transferable

2 It should be anatomically or morphologically as near the lost tissue as possible

3 It must be available in adequate amounts

4 Its procurement must not result in functional perversion of the donor area

5 It must not result in permanent esthetic defacement of the site of origin

6 In the case of skin it must be esthetically appropriate from the standpoint of color, kind, texture, hair content, lines of tension and thickness

7 It should have potency of permanent functional survival or be directly responsible for functional rehabilitation

PREPARATION

If the donor site is normal tissue, it should be prepared by shaving, scrubbing with white soap and water well beyond the area, drying with ether, painting with alcohol and covered sterilely Tissues destined to become grafts never should be painted with tincture of iodine or any antiseptic preparations usually employed in general surgery Instead, the site should be prepared two or even three times as outlined in Chapter 11, 'Activation of the Surgical Plan"

Where the donor site is scarred, cornified or afflicted with one of the common eruptions and where no other site is available, local treatment must be instituted, such as physiotherapy hydrotherapy, chemotherapy, heliotherapy and general measures, before any attempt is made to use it as a source for grafts In case of doubt, wait! Nothing is gained by gambling with such tissue, much time may be lost and occasionally pain may be inflicted

The age old Hindu practice of beating the tissue to be used as a graft particularly in the case of skin has been brought to light again Mention of it will be found in recent literature, but the virtues of the practice and its advantages must await further experimental work and final clinical evaluation Apropos this practice heliotherapy and even blistering of the skin have been tried in the hope of increasing its potentialities of transfer and 'take There is no concrete evidence as yet that such conditioning improves the physiologic integrity of tissue or its biologic virtues

METHODS OF MOBILIZATION

STAGING OF DONOR AREA

When using the Padgett dermatome, certain conditions determine the feasibility of the donor site The site can be of almost any contour, but the skin should be loose thick and preferably with good quantity of subcutaneous tissue Hence the choicest donor areas are the abdomen, the buttocks, or the back The thigh is frequently used In the thigh there is some danger of cutting into the skin lateral to the drum of the instrument, especially where grafts are taken across the extremity rather than polarwise To avoid this unwelcome incident, the assistant must depress the skin, by tongue blade or otherwise, below the extremities of the blade to keep it from nicking or cutting into the skin

This can be circumvented in another way By placing a 1" wide rubber band on either side of the thigh area chosen for the donor site, or applying a 2" bandage snugly, the 'stage" is ballooned out over the normal

level of the thigh so that the knife blade in its to and fro motion glides over the skin collateral to the dermatome The success of this maneuver depends upon the position of the rubber bands or the bandage the compressibility of the subcutaneous tissue and the length of the thigh (Fig 110)

The conditions best suited for the free hand mobilization of skin is a donor site whose cutaneous covering is normally light quite flat straight and narrow Even so it is necessary for the areas immediately adjacent to the cutting blade to be subjected to additional tension so that the skin under immediate attack has a kind of drum head flatness This is accomplished by the use of the Blair suction block or two pieces of ¼ plywood each about 4 x 6 (Fig 109) The board parallel with the back of the cutting blade must remain stationary while the one preceding the sharp of the instrument with maintained pressure pull on the skin must proceed in the direction of cutting Brown recommends that the actual cutting be done as the blade is being pushed while some recommend cutting as the knife is pulled toward the body Still others prefer cutting during both the pull and the push phases The important factor ultimately resides in an accurate feel of the blade resistance as it passes through the skin thickness

A more recent manner of mobilization is the Caltegirone method accomplished by gluing a resilient ribbon of steel of specific width and thickness to the donor site and then projecting the ribbon through the slit of a special blade This blade splits the skin by progressive undercutting to the opposite terminus of the metal ribbon The skin graft stays glued to the ribbon hence does not curl on the knife blade and is of predetermined geometric thickness It is a method basically akin to that of Padgett but more simple and less cumbersome though not quite so accurate geometrically The dermatome is electrically operated

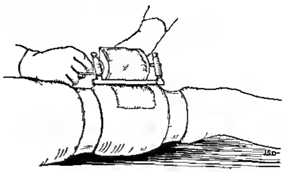


FIG 110 Pick s method of safeguarding skin outside dermatome blade Tape or 2 inch gauze is tightly strapped about the thigh to produce bulging of donor site as shown This method is most satisfactory in cases with adequate compressible subcutaneous fat Often only the distal strapping is necessary

Epidermic and Split Grafts

All free skin grafts whatever their form

FIG 109G Methods of mobilizing free grafts (*Continued*) Steps in cutting of split graft via Padgett dermatoma (*Top left*) Note application of single layer of glue to drum, which is preceded by similar application to donor site Before exposing drum to donor area wait until both are obviously dry (usually 5 minutes) (*Center, left*) Note careful and accurate level apposition of drum to donor site Assistant is flattening sides of donor site for protection against nicking by knife blade (*Bottom left*) Rotation of drum practically completed covered by split graft taken across thigh Note assistant s flattening borders of donor site with tongue blades (*Top, right*) At completion of cutting dermatome is carefully laid convex drum up, corners of graft minutely picked up by hemostats and graft wiped from drum with powder soaked gauze wrapped about index finger (*Center, right*) Where proximal extremity of graft is not amputated by Padgett knife with ease and accuracy graft is removed from drum as in 4 dermatome laid to one side and graft cut from donor site with scissors as shown (*Bottom right*) Graft is then powdered on epidermic side by sterile talcum or sulfanilamide to prevent glue remaining on graft from pleating and sticking to itself It is then sutured into recipient site as shown

or shape may be mobilized either by the scalpel razor or one of the several derma tomes As a general rule the less than full thickness skin grafts—that is the epidermic or split grafts—are mobilized by a derma tome such as the Padgett the Caltegirone or free hand by a razor type of instru ment such as the Blair knife (Fig 109)

Clinically the choice of mobilizing in strument is usually made as follows where a wide area of no more than 8 in length is to be covered the Padgett dermatome is the choice instrument but where strips of skin less than 3 in width but more than 8 in length say up to 20 are needed the free hand method though geometrically less accurate is more practical time saving and less involved The latter needs more prac tice finesse feeling and experience in mobi lization but with experience comes knowl edge and recognition of micro anatomic thickness of graft while cutting which is only possible with the more complicated dermatomes through biopsy determinations

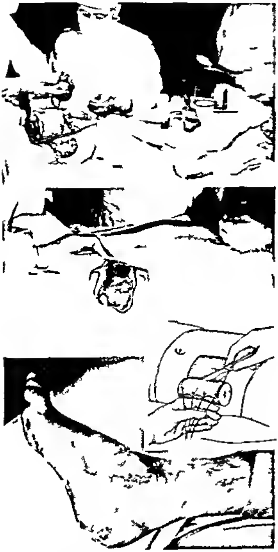


FIG 111A Mobilization of full thick ness free skin graft (*Top*) Mobilization of full thickness free skin graft via Padgett dermatome Note depth of donor site which must be regrafted by a split graft to avoid deep scarring The exact level at which to cut is determined by buttonhole biopsy (*Center*) Lesion for which graft is intended It is an in dolent burn ulcer which practically en circled the foot at heel instep level (*Bottom*) Results with full thickness skin graft (*Inset*) Free hand mobiliza tion of full thickness skin with gauze roll as staging medium

FULL THICKNESS GRAFT

The full thickness free skin graft as is the case with the mobilization of all pedi cles and flaps is usually done with the scal pel Different authors have a different man ner of procuring full thickness skin These may be divided into two classes

The first method consists of excising a block of tissue of skin and subcutaneous fat Then by careful and meticulous re moval of the fatty tissue from the inverted skin the latter remains as a free full thickness graft The second is the method of carefully and meticulously dissecting the skin per se away from the underlying fatty tissue which then may or may not be ex cised prior to closure of the surgical defect (Fig 111) The important thing to remem ber is that there must be no subcutaneous fat on the underside of the skin when the latter is intended as a graft because a full thickness skin graft is mere skin and nothing more Skin with subcutaneous tissue ceases to be a full thickness skin graft but becomes a compound graft and cannot be

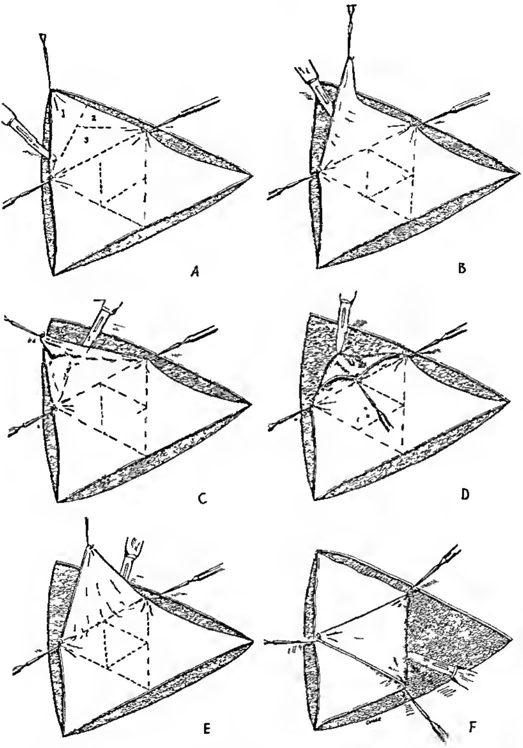


Fig 111B Mobilization of full thickness free skin graft (*Continued*) Rhythm of undercutting in mobilizing patterned full thickness free skin graft by triangulation This allows for short sweeps of knife, a far more accurate method than when the entire edge is undercut at one time Latter leads to buttonholing This approach is particularly advantageous in grafts with complex outlines

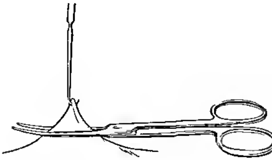


FIG 112 Mobilization of Davis pinch graft A better graduated graft is obtainable when a slightly curved on flat scissor is used than a straight one

free transplanted as such with much success unless of pinch type size

There is one important technical consideration in the mobilization of a full thickness skin graft as against the acquisition of split grafts and that is its designing A full thickness graft always should be cut so it exactly fits the defect to be repaired This is accomplished by tracing the defect on some transparent material such as cellophane or washed X ray film with cresyl green or methylene blue The area bounded by aniline dye is then cut out and laid on the donor site It is there transferred by retracing onto the skin which is then incised within the aniline lines only through the epidermis This establishes accurate outlining of the proposed graft The entire thickness of the skin is then incised and mobilized as a full thickness graft Basically it is the same principle as illustrated in Figure 25

Full thickness grafts may also be taken via the Padgett dermatome This is particularly expeditious where a large graft is needed up to 4 x 8 in With this method the exact thickness of the skin in the donor area must first be determined This is accomplished by making a buttonhole incision just outside of the area carefully dissecting up the skin of one lip of the incision for a distance of one quarter inch and applying a micrometer to it Where this is not feasible then a rough determination of thickness can be made with dividers and the skin removed with possibly some subcutaneous tissue on it This is then dispensed with after the mobilization by free hand excision with scissors Wherever a full thickness free skin graft is mobilized the donor area must be closed by direct approximation of its skin edges if possible Where the remaining donor area is so large it cannot be closed a split graft from a second donor area must be secured and placed into the primary donor site

DERMIC GRAFT

The derma proper of the skin may be acquired by first shaving the epidermis away either free hand or if a large sheet by means of the Padgett dermatome set at 0 006 8 in The derma is then dissected up from the subcutaneous tissue The raw area which remains is covered by the epidermis originally shaved away to expose the derma. The epidermis is merely basted in place and dressed as any other free graft

PINCH GRAFT

The pinch graft (Davis type) is included here although it is very rarely employed by the plastic surgeon except in selected cases of punched out defects It does have its one or two specific indications and is different in composition from all other skin grafts It is acquired by raising a cone of skin by needle or hook (Fig 112) bringing it to an acute apex and then snipping the raised point of skin below the hook This results in a rounded island of tissue up to 3 cm in diameter which differs from all other skin grafts in that its zone of circumference is epidermic its center is full thickness and the zone between the two is a gradual transition from epidermis to full thickness skin (Fig 103) This results in certain physiologic and clinical advantages not to be found or possible in large sheet grafts (see Indications this chapter)

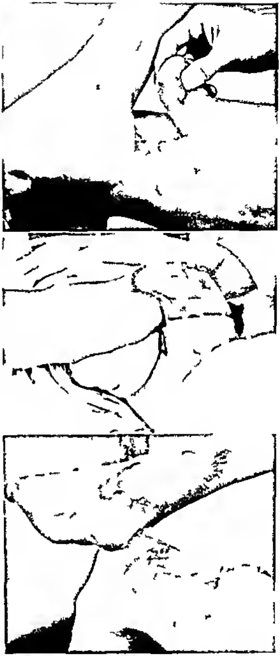


FIG 113 Pincushion flap (Pick's technic) (*Top left*) The pincushion flap is a type of pillowed pedicle made by suturing the free distal extremity to the underside of the peduncle and free grafting the donor site with a split graft This is a 1 stage procedure best suited to cases *with adequate subcutaneous fat* Where latter is minimal it is better to raise flap in 2 stages (*Bottom left*) To show position of flap when dressed postoperatively (Fig 74A) as well as mobility and approximated distal end to base of peduncle (*Top right*) Preoperative trial run in opposing recipient to donor sites (*Center right*) Pincushion flap opened and implanted into recipient site after complete excision of all scar tissue freezing Achilles tendon and ankle Dark lines across proximal aspect of pedicle indicates distal extremity of free grafted peduncle as well as line of contact between flap and leg Note black roll of gauze between free-grafted peduncle and thigh This maintains necessary pressure for take of free graft Note point of entry of missile in sole of foot (*Bottom right*) Pincushion flap amputated and sutured over Achilles tendon Sutures ready for removal 9 days postoperatively Note depth of defect in donor site due to taking of full thickness of fat with skin—an important item in making flap in one stage Circular defect in distal end of donor site is pressure necrosis of split graft due to insufficient padding between ankle and thigh This particular flap transfer survived in spite of severe streptococcus infection in distal part of flap one of the advantages of this type of graft (Pick J Internat Coll Surgeons 10 28 41)

FIG 114 The rotated cervical flap (same case as Figure 6B) Suture line shows temporomandibular extent of excised congenital hemangioma Temporal region and cheek reconstructed with broad cervical flap brought up from submandibular region (3 weeks postoperative) Note good color and timber of new cheek Lighter area under lower lid and extending over side of nose is full thickness free skin graft applied at same time as flap (For final result see Chapter 30) (See Plate 15)

PEDICLES

The transfer of tissue in the form of a flap never should be undertaken without proper planning and designing of the flap Before designing it particularly if it is to be taken from one extremity and transferred to the other one should make certain that the joints of the one to be bent are not ankylosed It is grossly embarrassing after making the flap not to be able to carry it to the recipient site because the extremity is unbendable in the necessary direction The aligning of the extremity (carrier) with the recipient site is a must trial test before operation It is good practice to go through the ceremony of actually bandaging the carrier to the recipient site or vice versa This will elicit response from the patient as to the discomfort of the proposed setup Where the patient is antagonistic to a plan of transfer there will be trouble in store postoperatively if the patient is uncomfortable

Replanning is better than reoperating

The method of mobilization of any pedicle depends entirely upon the number the size and the composition of its peduncles as well as the length of the flap The outlining incisions in all of them are made through the subcutaneous tissue Their longitudinal extent is determined by the width of peduncle or point of attachment to the donor

FIG 115 Results after excision of fiddlestring scar binding mandibular region to neck and correction by Z plasty (19 days postoperative) Upper extremity of Z now curves snugly over the mandible instead of running in a tight straight line to the neck (see also Figs 36 and 45)

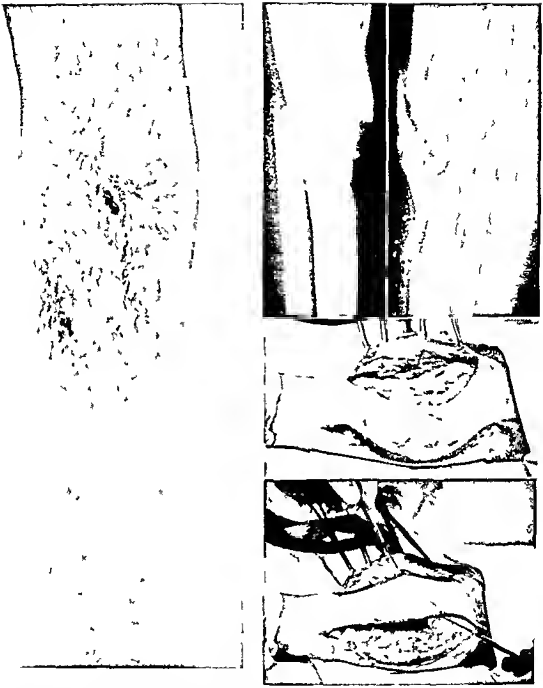
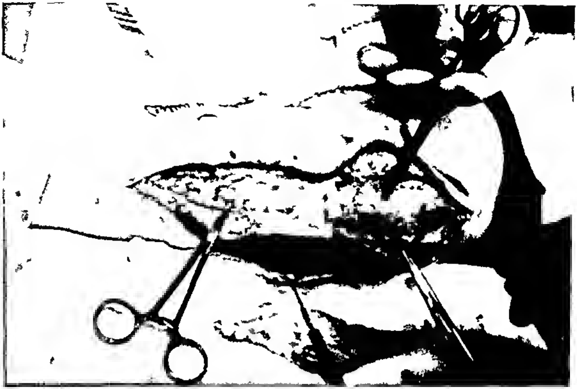


FIG 116A The "bridge" flap as used for reconstruction of grossly injured leg (Pick's technic) (*Left*) Extensive (compound comminuted) fracture of left tibia The small black area in the scar is a protruding fragment of tibia Note edema of leg (7 months posttraumatic) (*Right, top*) Roentgenogram of figure at left Note metallic foreign bodies and bone absorption (*Right, center*) Entire scarred area including attached bone fragments (dead) undermined and ready for excision Note deformed tibia at proximal end Deep concave incision on outer aspect of leg outlines future 'bridge' flap and is made to a depth only halfway through subcutaneous fat (*Right, bottom*) "Bridge" flap is formed by cautiously undermining skin and one half the thickness of subcutaneous fat Note deep layer of fat still covering leg muscles Flap has been shifted medially over tibia Scar defect still attached medial to tibia for purposes of illustration (Pick Am J Surg ***69*** ***25*** ***28***)



area Some surgeons routinely make the two parallel incisions first and undermine the ribbon of tissue thus outlined After two weeks the distal points of the two parallels are connected and undermined About two weeks later the flap is re incised on all three sides undermined to its peduncle and made ready for transfer if at this point it does not show signs of circulatory embarrass ment

When doing final mobilization of a flap the incisions should be made so as to leave the scars of former incisions behind These are then excised before grafting of the donor site *To leave any of the original suture* lines on the transferred flap is to loose it because one of its most important entries of blood supply are its edges Vessels will not grow rapidly enough through a scarred edge to save the periphery of the flap from necrosis This applies to all pedicled tissues Allowance for tissue cost is planned

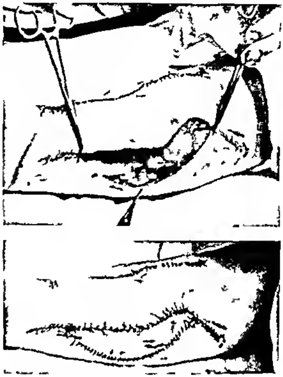


FIG 116C The bridge flap as used for reconstruction of grossly injured leg (*Continued*) (*Top*) Showing possible reduction in size of surgical defect after shortening of leg circumference via fat excision This phase of approximation must not be carried to point of tissue tension (*Bottom*) Dermoplasty com pleted via free full thickness skin graft taken from thigh of same leg Note com paratively small free graft (minimal tis sue cost) necessary for completion of procedure (see Fig 116D) (Pick Am J Surg 69 25 38)

FLAP RATIO

In designing of flaps it has been found by experience that survival depends to a great degree upon the relation of its length to its width This is somewhat dependent on the part of the body upon which the flap is designed the amount of subcutaneous tissue and the quality of circulation In general it is safe practice not to exceed a length base ratio (L B R) of 2 to 1 if a flap is prepared for immediate transfer and 3 to 1 if the flap is prepared in steps as out lined heretofore By practicing repeated delay a flap at times may reach a ratio of 4 to 1

TRANSFER BY DELAY

When a flap is necessary whose length base ratio exceeds 2 to 1 or if one has

FIG 116B The bridge flap as used for reconstruction of grossly injured leg (*Continued*) (*Top*) Scar excised and laid out on towel under hook retractor Medial edge of bridge flap has been sutured to healthy skin on inner aspect of leg Deep layer of fat has been incised along free edge of flap and partially dissected from underlying muscles being certain not to injure deep fascia indicated by hemostat in hand Hemo stat near distal angle of wound is on deep perforating vessel Hook retractor holds skin of posterior leg everted so fat sheet can be dissected free around back of leg if neces sary This shortens leg circumference (*Bottom*) Showing wide ribbon of subcutaneous tissue being removed from posterior aspect of leg to further shorten leg circumference This makes the skin covering of leg relatively larger allowing for at least partial closure or donor area on side of leg (Pick Am J Surg 69 25 38)

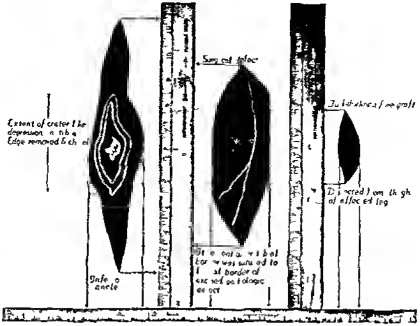


FIG 116D The bridge flap as used for reconstruction of grossly injured leg (*Continued*) Comparative (exact pattern) size of original scar excision (left) surgical defect or donor site (center) and full thickness free graft necessary to cover surgical defect after latter s reduction *by shortening leg circumference* The pattern material is transparent x ray film Dotted area within first pattern illustrates extent of cavitation of tibia White center is position of protruding fragment of tibia (Pick Am J Surg 69 25 38)

reason to question the circulation of any flap it is necessary to replace the flap in its original bed (Fig 58) This is known as delay Its only purpose is to augment the ramifications of blood vessels within the flap and fortify its venous drainage This may have to be repeated 3 to 4 times

Delay has certain drawbacks from a physiologic standpoint Every surgical re intervention means just that much additional trauma to the subcutaneous tissues If done carelessly or repeated often enough there results considerable fibrosis of the subcutaneous fat This ultimately interferes with the venous drainage of the flap and so defeats the purpose of the idea of delay For no matter how efficient the arterial supply if venous drainage is inadequate, success is problematical More flaps are lost because of venous collapse than through arterial failure Hence, the ideal flap is one which is so designed as to be transferable immediately upon its mobilization, or possibly after a single delay

Pincushion Flap (Author s)—A Type of Pillowed Pedicle

The exigencies difficulties and delays in the construction of the conventional single peduncle flap can be circumvented to a large extent by the pin cushion flap or pillowed pedicle The latter embodies within it the cardinal virtue of the tube, viz thus it is a closed surgical system

A single pedicle flap is designed as usual, and all three of its edges are incised during the first surgical procedure The flap is undermined to its peduncle Instead of re placing it in its original bed as would be the conventional way to insure its circulation, the distal end is sutured to the under side of the root of the peduncle The sub

cutaneous tissue is approximated with plain catgut and the skin with dermal or horse hair The parallel edges of this cushion of tissue are then sutured to each other as is shown in Figure 113 This creates what actually is a tissue cushion (a pillowed pedicle) The latter designation is quite apropos the conventional term tubed pedicle The raw donor surface remaining after pillowing of the flap is simply free grafted as is done in all other procedures where a raw surface remains Due to the fact that in the pillowed pedicle the distal free extremity of the flap is immediately sutured to its own arterial supply in the peduncle (in contrast with the conventional delayed flap whose distal extremity is resutured to its venous supply) it enjoys a better and quicker rate of survival than the delayed flap

The pillowed flap is not feasible in under nourished or thin individuals or those who have a scarcity of subcutaneous tissue The integrity of the distal extremity of the flap is vitally dependent upon an adequate subcutaneous blood supply In such instances where subcutaneous tissue is negligible it is better to delay the flap once before pillowing One delay is all that is ever necessary in contrast with the open flap The points of advantage are

1 The pillowed pedicle flap is created in one surgical inning

2 *The distal free end of the newly created* flap by being immediately sutured to the proximal arterial supply of the flap survives much more formidably than if delayed in the usual manner

3 The fatty tissue of the flap shows very little if any postoperative fibrosis when the flap is eventually opened for transfer

4 It can be re opened and transferred earlier than if the simple conventional delay is practiced

FIG 116E The bridge flap as used for reconstruction of grossly injured leg (*Continued*) Results of dermoplasty 4 weeks postoperative Note good soft appearance of bridge flap and well healed suture lines Small black spot in proximal t p of free graft is due to subcutaneous cotton suture working its way to the surface (Pick Am J Surg 69 25 38)

FIG. 117A. Dermoplasty of leg (without having to free-graft surgical defect). (*Left, top*) Circumincision of scarred defect. (*Left, center*) Excising of scarred defect. (*Left, bottom*) Excision of scarred defect completed. (*Right, top*) Collateral tissues undermined, practically shelling out leg, dead bone removed with scar tissue, and soft tissue pedicles laid in to ablate dead space. (*Right, center*) Bridge flap mobilized and being shifted over tibial defect. (*Right, bottom*) Closure of defect over tibia. Note size of secondary surgical defect (donor site), also thickness of subcutaneous fat on back of leg.

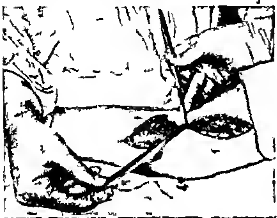
5. It is far more elastic than the delayed flap.

6. There is no tendency to postoperative puckering.

7. There is less tendency to postoperative pigmentary changes, even where other complications intrude after operation.

8. The flap has a decidedly better chance of survival if a postoperative infection sets in, because it has a more formidable circulation than the conventional delayed flap.

9. The management and surgical hygiene of the donor area is made easier because



the recipient site does not have to be brought into the picture until the grafted donor area is healed

10 The ultimate cosmetic results in the donor area are much better

11 Because of the flap s better physio logic integrity the problem of splinting of the flap to the recipient site is a less anxious one

12 Last but not least this type of flap has the subtle advantage of being transfer able at the discretion of the operator The conventional flap must be transferred before its raw surface establishes complete com munion with its source of orig n thereby necessitating re delay

Two precautions are necessary in the management of this flap After the forma tion of the flap constant minimal traction is necessary This should be applied only

FIG 117B Dermoplasty of leg (*Co tinued*) (*Left top*) Removal of fat from posterior aspect of leg to shorten its circumference (*Left center*) Possi bility of closure without free graft due to shorter leg circumference (*Left bot tom*) Undersurface of skin approxi mated Ready for skin closure (*Bot tom*) Dermoplasty completed Note line closure of original defect as well as surgical wound Gauze strips glued to skin help rel eve skin tension (comple mentary coarctation) These must not be so t ght as to interfere with circula tion of flap

at the point where the flap is folded upon itself and not to the entire surface (Fig 113) Actually no stretching of the tissues occurs when traction is applied over the entire area of the flap On the other hand, it does result in too much pull on the root or peduncle thus obliterating the arterial supply or separation of the line of approximation under the peduncle

The only other and obvious precaution is that at the time of the unfolding of the flap one must be careful not to cut into the circulation of the peduncle That is not an impossibility when the underfolded half of the flap is being laid out into its original length

After the unfolding the remainder of the reparative procedure is the same as in the case of the conventional flap (Fig 113)

French Flaps (Contiguous Flaps)

These are flaps designed adjacent to a defect to be immediately shifted or rotated

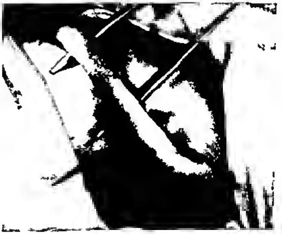


Fig 118 The tube (*Left top*) Preparation of large thoraco-epigastric tube A long *incision (in this case the left) is made down through subcutaneous fat Tissues are* undermined to a distance one third of the length of original incision with caution so that when large vessels are encountered they may be preserved Another incision parallel to the first is then made avoiding severance of the larger subcutaneous vessels Hemostat indicates presence of large vessel A bridge of tissue is left at such points so as to allow entrance of vessel into tube Bridge may be cut after the ninth day (*Left center*) Guide sutures are placed as shown at points previously indicated These allow tube to be turned into easy suturing position and to elevate same when closing the donor site (*Left bottom*) Tube closed Note bridge of subcutaneous arterial supply over hook (*Right*) Donor site closed with exception of portion under peduncle to illustrate relaxation necessary at that point thus avoiding constriction of circulation to tube

into it They constitute one of the ideal methods of plastic repair from the stand point of tissue cost, time expense and esthetic results The visualization of reconstruction by French flaps is often the most difficult It demands experience and imagination, but once mastered, it becomes the sine qua non of fine reconstructions All defects cannot be reconstructed by French flaps, but it is amazing how the percentage of possibilities increases with experience and resourceful application of the method (Figs 114 and 6B Plate 15)

French flaps are more frequently triangular flaps, but can be of any size and shape They are sometimes referred to as rotation, shift or advancement flaps This merely emphasizes the possibilities of their use Their greatest virtue lies in the fact that by their use one stage operations can be performed where with other methods several surgical innings may be necessary Secondly, repair by contiguous (French) flaps is the most economical from the stand point of tissue cost Rarely is it necessary to free graft the donor area since it is geometrically so outlined as to permit immediate closure Dupuytren Imre Szymanowski, Dieffenbach and Blaskovics were master users of this type of repair

One cardinal precaution must be born in mind constantly, particularly on exposed parts of the body, flexor surfaces genitalia and orifices, and that is not to produce surgical distortion of adjacent regions, by faulty planning over rotation or advancement of these flaps This can be overcome to some degree by wide undermining and secondary excisions at crucial points (see Chap 21, 'Surgical Geometrics")

"Z"-Flaps

Strictly speaking, the "Z"-plasty is based upon and belongs in the category of French flaps (Fig 115) By custom it is ordinarily set apart from the general discussion of contiguous flaps The principle underlying its *use is the revision of tension, position and* distortion of tissue and avoidance of 'fiddle string" contractures, rather than ablation of a defect per se However, as will be shown in Chapter 21, 'Surgical Geometrics,' the idea of the Z" plasty can be used for the single purpose of circular defect ablation

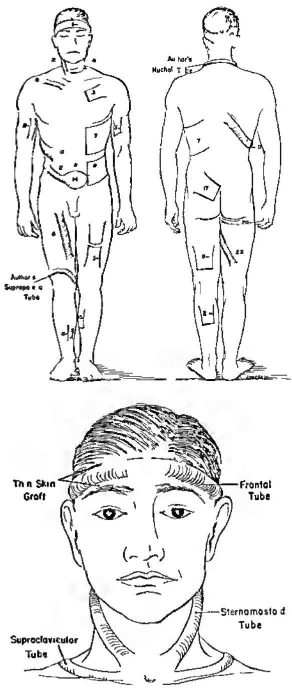


Fig 119A (*Top*) Certain donor sites for tubes and pedicles (*Bottom*) Tubes particularly fitted for facial repairs

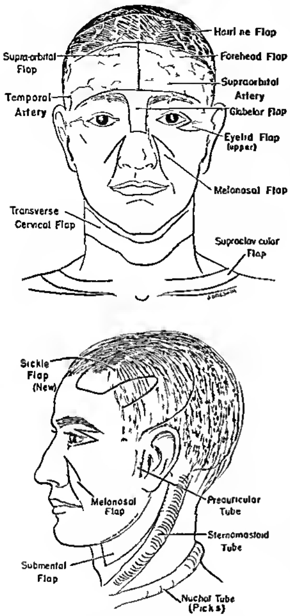


FIG 119B (*Top*) Facial and cervical flaps and their more common uses The supra-orbital flap (shaded) is used for repair of the nose the transverse cervical flap, for the chin the hairline flap, for the lip and the chin where beard is desired the forehead flap, for the nose and the cheek the glabelor flap, for the upper nose the melonasal flap, for the upper lip (*Bottom*) Fascial and cervical tubes and flaps and their uses (profile view) The sickle flap is used for repair of the nose (New), the submental flap, for the jaw, the cheek and the ear, the preauricular tube, for eustachian and ear repair, the sternomastoid tube and Pick's nuchal tube (encircling neck), for ear, nose, jaw, lip and oral repair

to avoid free grafting, which is one of the basic purposes of French flaps

The 'Z" plasty was first employed by Denonvilliers in 1856 and explained mathematically decades later by Lemberg It always will remain as one of the cornerstone procedures in plastic surgery Since it is most frequently employed in scar relaxation, its execution will be described in that connection (See Chapter 17, 'Surgery of Scars" For principles of 'Z" plasty, see Chapter 21, 'Surgical Geometrics")

DOUBLE PEDUNCLE FLAPS

These are sometimes referred to as bridge, tunnel or hammock flaps

The double-peduncle flap, created on the same principles as the single peduncle flap, differs from the latter in that its third side is never cut Therefore, it has two peduncles, no free end cannot be rotated, advanced, transposed or pillowed, but allows only of being lifted or shifted In the first instance it becomes a *tunnel* flap and in the second a *bridge* or *hammock* flap (Figs 116 and 117) Hence, it cannot ordinarily be 'carried' to other parts of the body, but instead such injured parts must be brought to it On the other hand, it can be tubed and in that state "waltzed" to any part of the body

When its movable center is shifted into an adjoining defect, as indicated above, it is referred to as a *bridge* flap, when the injured part is brought to it and insinuated under its loose center, it becomes a *tunnel* flap, and when it is elastic and long enough to be transferred over a contiguous healthy part to a defect beyond, it may be designated as a *hammock* flap

The advantages of a double peduncle flap are better blood supply, minimal disturb

FIG 120A Clinical use of donor sites (tubes and flaps) (*Left*) Use and first stage application of brachial tube in reconstruction of chin and lower lip Though unwelcome because of the arm position in some patients this donor site is unavoidable (*Right*) Hyomastoid tube for reconstruction of helix Also posterior auricular tube shown in place for reconstruction of auditory canal An existing traumatic perforation of the concha was taken advantage of to waltz postauricular tube to auditory canal (For method of its final insinuation, *see* Chap 27 Ears)

ance of innervation and good lymphatic drainage Hence the possibility of increasing its length base ratio (L B R) Its greatest virtue and most practical application resides in the fact that a large volume of well nourished dependable tissue can be shifted into an adjacent defect thus ablating it in one operation in depth as well as surface extent The surgical defect created by the tissue shift is then free grafted It is the choice procedure from the standpoint of both time and tissue cost whenever it can be called upon (see Chaps 28 and 29)

THE TUBE

The double peduncle flap can be turned into a tube by approximating its free edges in a turned under fashion This creates a closed out of an open surgical system so that no raw under surface remains and the tissue does not have to be applied to a defect immediately (Fig 118) More than that, it can in the tubed state be waltzed or transferred one peduncle at a time to any part of the body without fear of shrinkage distortion infection or death due to ex

posure of raw surface It is important in the making of a tubed pedicle that the parallel incisions or in other words the polarity of the contemplated tube run in the direction of the arterial supply of the part Hence tubes are usually made in certain elected regions such as the hypochondrial thoraco epigastric thoraco abdominal thoraco acromial sternomastoid scapular iliofemoral and others less frequently employed the suprapatellar (author s) nuchol (author s) subhumeral medial tibial submental etc Tubes are usually identified by the location of their peduncles viz thoraco epigastric (Figs 119 and 120) The idea is Filatov s (1911) or Gillies (1913)

Tubing of Double Peduncle Flap

Two parallel incisions are made whose distances from each other must be no less than one third of the length of the parallels The length of a tube is determined by the integrity of the circulation of the donor site the amount of tissue needed for repair plus an adequate peduncle which will be necessary to bridge the distance from attachment to the carrier The parallels are than divided into five equal parts by cresyl green or methylene blue The inner three fifths of the freed edges are turned under by guide sutures and approximated with accuracy The outer fifths remain open forming the peduncles and are sutured back into their original place after undermining and approximation of the lips of the surgical defect The latter can be accomplished in three ways by conventional closure of the surgical defect the Bunnell procedure or the author s modification of the latter (Fig

Fig 120B Clinical use of donor sites (*Continued*) (*Top*) Sternomastoid tube containing section of clavicle and destined for reconstruction of glabella and nose This type of tube with bone graft included is not recommended for routine use (see Fig 123 *top*) (*Bottom*) Sternomastoid tube to include section of clavicle intended for reconstruction of ear and buttressing of lost zygomatic bone

121) Bunnell s procedure avoids the super imposition of the line of tube closure upon the suture line of the donor area thus dispensing with the fear of maceration It is a method particularly adapted to regions where one of the lips of the surgical defect consequent upon making of the tube consists of skin far more elastic than its mate or where it is not possible to undermine one of the lips so it can be shifted centrally Where only the oblique poles of the wound lips can be undermined the author s modification may be employed

Where approximation of the lips of the donor site must be done under tension it is better to *free graft* the surgical defect (Fig 122)

When tubing is completed the space intervening between the closed donor site and tube must be covered by dressings It is imperative that the tube be dressed or splinted in suchwise as to absolutely avoid kinking or tugging of its peduncles or pressure on the tube (Fig 123) which a roll of gauze on both sides of the tube avoids

Transfer or Waltzing of Tube

After two to three weeks depending on the size and the circulation of the tube one of its peduncles can he transected opened one fifth of its extent and transferred to a carrier or the site of reconstruction The recipient site for the severed peduncle must be properly designed so as to offer the maximum surface esthetically permissible for adequate circulatory communion with the peduncle This is usually accomplished by some type of trap door design consisting of a half moon flap a triangular flap or the author s Y trap (Fig 124) Where exceptional mobility of a transferred peduncle may be an advantage the Y trap may be modified into an arrowhead trap (Fig 125) As a rule this is practicable only in regions where abundance of subcutaneous tissue exists so that the recipient incisions need to go through only the superficial layer of the fat A tube thus attached can

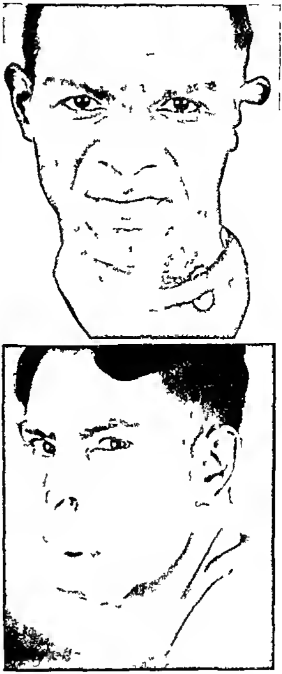


Fig 120C Clinical use of donor sites (*Continued*) (*Top*) Supraclavicular tube destined for reconstruction of left ear For final results see Figure 259 (*Bottom*) Nuchal tube (Pick) intended for reconstruction of nose and mouth Although this type of tube supplies much tissue it is relatively difficult to make and handle This applies to all tubes crossing the body midline

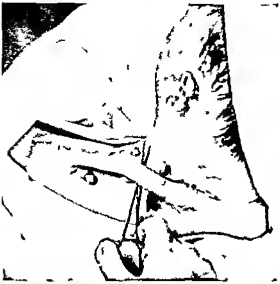


FIG 120D Clinical use of donor sites (*Continued*) (*Left, top*) Acromionuchal tube (left) intended for total otoplasty This is only resorted to where per aural and cervical tissues are not available as in extensive burns of the head, face and neck (*Left, bottom*) Infrascapular tube intended for recon struction of anterior neck and chin This patient had no available tissue on the front of the body because of an exten sive third degree burn (*Right*) Thoraco-epigastric tube destined for release of elbow contracture as shown For result see Figure 285, pp 532 534

more safely be pulled upon or rotated on the peduncle axis without the usual fear of kinking its blood supply The rotation may exceed 90 degrees

Once the trap is prepared, the free end of the tube is anchored to the recipient site by one catgut suture in such a way that it is centered on the site Another fine catgut suture then approximates the tip of the tube to the arc or the apex of the recipient site, depending upon the shape of the site The skin of the tube must then be accurately sutured to the skin of the recipient area After three or four weeks the other peduncle of the tube may be waltzed and jumped to its predetermined recipient area, usually the site of repair (Fig 126) There must be no scar tissue in pedicles in transfer

In using the author's type of trap doors, it is necessary when mobilizing tube pedun cles to excise rather than transect them The difference lies in the fact that whereas in the latter method the tube peduncle is simply cut across, in the former the circum-incision of the peduncle is made into the depths of its attachment to the donor site so a projecting "cork" of subcutaneous tissue is taken with it This then fits into the depths of the collar formed by the "Y"

FIG 120E Clinical use of donor sites (*Continued*) Abdominal tube destined for reconstruction of left forearm as shown

or arrowhead trap whichever is designed to receive it (Fig 126)

After the lapse of another three or four weeks the underside of the center of the tube now reposing over the major portion of the defect is opened by removing the scarred tube closure or suture line deep into the substance of the tube Only thus can the tube be spread into a ribbon of tissue which can then be sutured down into the defect (See Section 3)

On the premise that the most important initial circulation garnered by a transferred tube from its recipient site is by means of its skin Charles Claoue of Paris modifies the usual procedure (personal communica tion) He removes the epidermis from the terminal one quarter inch or more of the tube and then buries the tube completely in the recipient site (Fig 127) Theoretically the suggestion is a good one but in practice the resulting tissue cost is a sacrifice not always permissible especially where a tube has to be waltzed several times because the epidermal decortication of the end of the tube makes it esthetically undesirable for ultimate surface repair

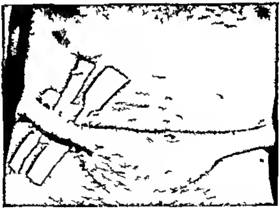


FIG 120F Clinical use of donor sites (*Continued*) Transabdominal island tube This type of arrangement is useful in gross loss of tissue encircling the knee The central island of tissue makes good coverage for the patellar region while the tubes can be draped around the back of the knee to reconstruct the popliteal space

COMPLICATIONS

Operative

The most important complication encountered *during* operation in the preparation of flaps or tubes arises from interference with the arterial blood supply This may be the result of severance of the main arteries within the deep layer of subcutaneous tissue minutes, the flap may be tubed or transferred according to plan Sometimes the postoperative administration of atropine sulfate gr 1/150 q 5 hours for 3 doses aids in the maintenance of cutaneous vasodilatation with the saving of the flap Heat of 104° F should be applied to the dressings *over* the flap but never to the flap itself

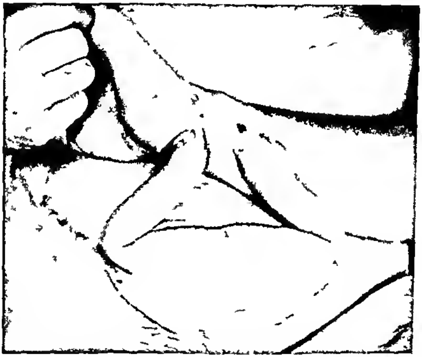


FIG 120G Clinical use of donor sites (*Continued*) Transabdominal island tube shown in process of waltzing via left arm as carrier The midline abdominal defect left after complete mobilization of the island can usually be closed by direct approximation

or a reflex vasospasm Nothing can be done about the former except to replace the elevated bridge of tissue in its original bed If gangrene does not supervene then it may be re elevated three weeks later In the vasospastic flap application of wet hot compresses to the flap may relieve the spasm If the deathly pallor of the flap is not replaced by definite capillary reaction within five to seven minutes the tissue must be replaced and resutured If a capillary reaction can be elicited after the lapse of seven

In massive tubes with acute arterial embarrassment, particularly where the patient is afflicted with temporary anoxemia for some reason the administration of oxygen by inhalation will help materially to revive it If the patient has lost a telling amount of blood during the operation even a blood transfusion is indicated for the sake of the tube as well as the patient The expense is preferable and the cost much less than the difficulties connected with the making of another tube

POSTOPERATIVE

The most frequent postoperative complications with tubes or flaps, excluding infection, are of venous origin This is always more certain where haphazard or cruel dissection is employed A certain amount of postoperative edema and lymphstasis always occurs in the flap If this is sufficient the resultant interstitial pressure will occlude the venous return This in turn will augment tissue pressure upon arterial inflow, so that a vicious circle results, leading to wet gangrene and death of the flap or tube This can usually be avoided by a closely fitted postoperative dressing which prevents the establishment of the vicious circle by avoiding excessive edema of the flap or the tube This pressure need only to be maintained between 36 and 48 hours when a circulatory optimum is established Once such pressure is applied, under no circumstances must it be lost or disturbed for at least 36 hours Peeking under such dressings out of curiosity to see what color the tube may be means disaster (Plate 11)

The next important complication is the formation of hematomas or seromas under the flap or within the tube Where this is suspected immediately after suturing of a flap, one or two sutures removed at the guilty looking point will allow for evacuation of the blood and ligation of the bleeder In the case of the tube, the problem is more complex, since it may mean reopening of the entire tube to ascertain from which one of the peduncles the bleeding originates Such an unwelcome act can usually be avoided by the following procedure An assistant immediately compresses the entire tube with his hands A tiny puncture hole is made into the unsuspected peduncle with the point of a #11 Bard Parker blade, only large enough to permit insertion of the smallest rubber catheter (Fig 128) The catheter is quickly pushed into the interior of the peduncle until it reached the other or distal peduncle, a 10 or 20 cc syringe is attached and aspiration is started The tube

FIG 120H Clinical use of donor sites (*Continued*) Femoral tube This type is useful for the repair of almost any soft tissue defect of the lower extremities

is flushed quickly as the assistant relaxes his pressure hold on the tube for a moment The saline is quickly aspirated and discarded while the assistant recompresses the tube The aspiration is then repeated, beginning at the distal peduncle If negative for blood, the catheter is slowly withdrawn along the interior of the tube while aspirating suction is maintained The assistant releases his hold finger by finger from the distal to the proximal peduncle of the tube while the catheter is pulled on toward the operator When the approximate area of bleeding is reached by the tip of the

FIG 120J Clinical use of donor sites (*Continued*) (*Top left*) Suprapatellar tube (Pick s) is very useful for repair of long narrow defects of the extremities or those of the popliteal fossae The donor site can be closed by direct approximation (*Top right*) Medial tibial island flap for collateral repair This type must be allowed to mature for some 6 weeks Notice the tunnel defect of the heel (*Bottom, left*) Submental flap This is useful in cheek or ear reconstructions Otoplasty via tube had been attempted (else

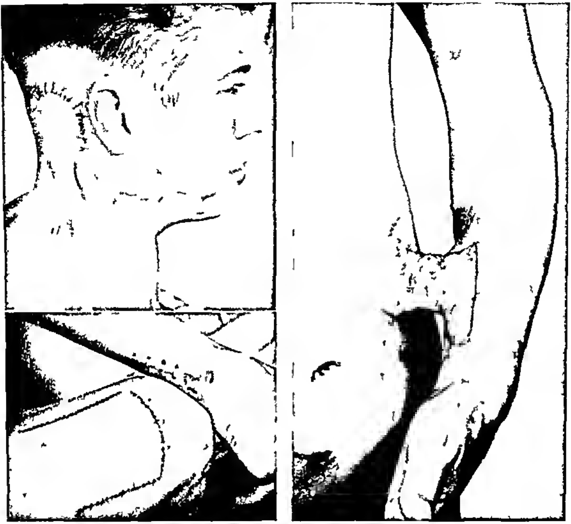


FIG 120K Clinical use of donor sites (*Continued*) (*Left top*) Tubed occipital island flap—useful in cheek and jaw reconstructions *in men* where beard must be provided Note deformity of lower jaw (*Right*) Direct transfer of abdominal flap to forearm—useful in most acute clinically clean deep or compound injuries of the hand or forearm (*Left, bottom*) Delayed femoral flap—useful for deep repair of contralateral leg or ankle region Delayed flaps should be originally made approximately 30% larger than defect indicates Hence tissue waste is much higher than without delay Contrast with Figure 113, right

catheter, bright red blood will appear in the syringe

This allows for limited reopening of the tube allocation and ligation of the bleeding point It is timesaving and dispenses with the disagreeable and traumatizing procedure of reopening all of the tube The tiny puncture of one peduncle creates no danger to its circulation

When a hematoma is observed later it must be immediately and carefully removed through a buttonhole in the flap or an open

FIG 120J (*Continued*)
where) resulting in inadequate reconstruction, as shown at right (*Bottom, right*) Results of total otoplasty based on the use of the submental flap shown at right Detailed modeling of the left ear is still needed

FIG 120L Clinical use of donor sites (*Continued*) Reversed femoral flap (peduncle above knee)—useful in most contralateral leg injuries This type of flap must be delayed at least once, usually twice, and must be carefully protected after implantation against weight of recipient leg on its peduncle and circulation It is never a flap or procedure of choice It has one minor advantage over conventional femoral flap—the donor site is more easily dressed (Note arrow on donor site)

ing made by removal of one or two sutures Immediately upon its evacuation, a pressure dressing up to 40 mm of mercury must be applied If the hematoma recurs, it means re elevation of the flap or opening of the tube and ligation of the bleeding artery The prognosis of such a flap or tube is poor

The next most probable complication, particularly with tubes arises out of kinking or tugging on the peduncle (Fig 129) Such trauma is most telling in the first one hundred hours of the tube Every effort during this period must be made to maintain adequate splinting and protection of it

Infections occasionally arise under flaps They never should occur in a tube Early infections may be treated by chemotherapy In the presence of frank pus drainage must be instituted In such instances transfer or further surgery should not be contemplated for three or four months, even if the flap or tube survives Ultimately they are usually inadequate for planned repair, due to too much fibrosis in the subcutaneous tissue

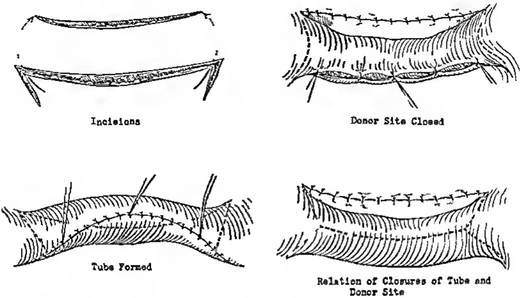


Fig 121A Closure of donor site for tubed pedicle (Bunnell's method) Although this cannot be employed routinely, wherever possible it obviates irritation of sub tubal closure of donor site

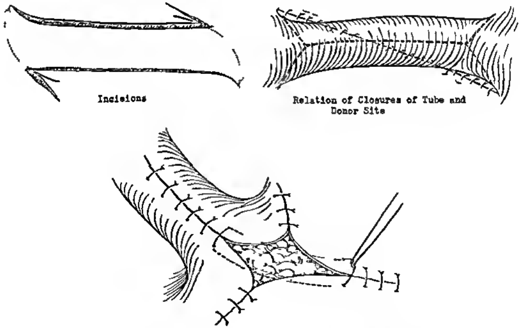


Fig 121B Closure of donor site for tubed pedicle (*Continued*) (*Top*) Pick's method Where Bunnell's procedure for closure of donor site is not feasible, the above obviates to a large degree direct irritation of closure by overlying tube It is more routinely applicable because extremity incisions into lips of the donor area can be reversed It also permits of easier and more complete closure of tube peduncles (*Bottom*) Gillies method for the closure of peduncle of tubed pedicle

Gangrene or necrosis of a flap may be the result of an extravagant length base ratio (L B R), pressure upon or twisting of the pedicle or preoperative arteriosclerosis with postoperative thrombosis of the vessels Pressure or twisting of the pedicle should be relieved and heat applied to the flap for 18 hours The practice of "pie crusting" or huttonholing of the flap is of little or no help in these cases It usually does more harm than good

FIG 122 Free grafting of donor site for tubed pedicle Where donor site is of such width that direct closure would result in tension on wound edges, it is necessary to free graft the defect under the tube as shown Note easy relation of defect to femoral tube

METHODS OF FIXATION OF GRAFTS

EPIDERMIC GRAFT

The epidermic graft as a rule, needs no sutural fixation If properly spread over the recipient area and pressed down for a few seconds, it will stay long enough to allow for application of pressure dressings, which are sufficient to hold it in place unless the part is of uneven or complex shape In that case some provision for splinting the graft such as a mold of dental compound, humid cotton, preshaped acrylic or sponge rubber must be employed The material is shaped to the size of the defect, the graft is wrapped or sutured about it, with the raw side out, and the ensemble is inserted into the recipient site It must then be secured into position as conditions permit

As a working rule, the epidermic graft can be laid and splinted to its bed with pressure dressings or basted to the edges of the wound Other things being right, it may be inspected on the fifth to the sixth postoperative day, at which time the graft should have taken" It is dried well and dressed dry for five more days It is then ready for exposure, but not for wear At night, for a period of two weeks applications of cocoa butter may be used This graft should take' in almost 100 per cent of cases and can even be placed into a contaminated or relatively infected field with fair chance of survival

SPLIT GRAFT

The split graft always should be sutured in place and adequately splinted by dressings In lining cavities or uneven defects, it must be applied over molds, rawside out, or molded into a defect by such reliable packing as humid cotton (Fig 130)

There is little question but what poor postoperative scars about graft edges are the result of poor apposition and suturing Much ado is made over the imperativeness of proper bone alignment in fractures yet little emphasis is placed on that same fundamental principle as it applies to the end results obtained in repair by grafting It has been my experience that meticulous apposition and splinting are even more important in soft tissue surgery than in bone surgery

The split graft after being dressed at operation should not be disturbed for a minimum of seven days unless complications set in Like all free grafts it should have one or two puncture drainage wounds in the place most dependent when the patient lies in bed Pie crusting of grafts is discouraged It leads to necrosis about the puncture wounds outgrowth of granulation tissue and poor cosmetic results If the recipient bed is perfectly dry no clots are left under the graft dressings over the graft are snug from one to three intelligently placed small puncture wounds depending on the size of the graft are all that is necessary (Fig 131)

The graft should be inspected on the seventh to the ninth day and should be dried and redressed in dry form for another ten days after which it can be exposed as a rule It is not wise to subject it to wear and tear until after an over all period of six weeks at least

Full-Thickness Graft

The full thickness graft must be sutured as perfectly as is possible into its bed under slightly more tension than exists at its point of origin because for from 75 to 100 hours it is forced to live on only the plasma which can be gathered up by the intercellular spaces from its new bed It is most important to have absolute and leveled layer-to-layer apposition of full thickness skin grafts with the skin of the recipient bed

Every third suture includes deep tissues

Fig 123 Methods of preventing tugging or kinking of tubes (*Top*) The recently imbedded pedicle of a cervical tube is protected against tugging or kinking by a strip of gauze glued in place with collodion and projected into forehead (See Fig 120B *top*) (*Bottom*) The danger of tugging on a tube attached to the ear is great A suture running from the ear lobe to the proximal tube attachment is a simple and quick method of control

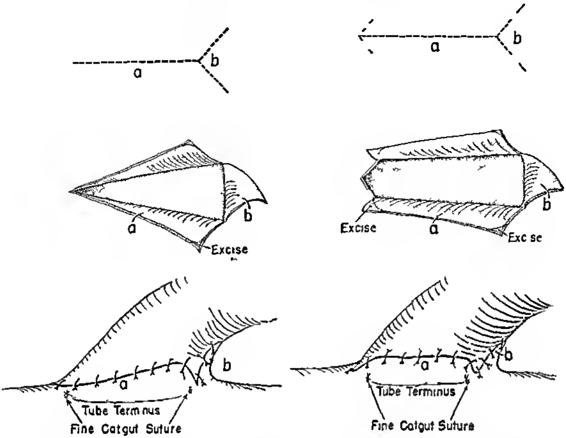


Fig 124 Pick s peduncle traps (*Left*) The Y trap for small tubes provides a separate pedicle b for the wedge shaped scarred area under tube peduncle which has to be excised in transfer of the tube The substitution of this scar by flap b makes the attached tube much more movable and yet less liable to kinking (*Right*) The arrowhead trap for large tubes has additional advantages over the Y trap This type of trap is especially indicated where the recipient site is difficult to approach with the suture needle or where its skin is hard to perforate Not only is anchorage of the tube made easier but on transfer of other pedicle the tube is more easily rotated to the desired angle without fear of twisting Additionally after transfer of peduncle raw area is more easily approximated

Splinting must be as nearly perfect as possible Dressings in the management of full thickness grafts are as absolutely important as anything which goes to make up the operation There is no standard dressing —only standard procedures in the dressing of full thickness grafts

It has been my practice to place one layer of fiberglas or xeroform gauze on the graft (Fig 132) This is superimposed by a layer of 1 to 2 inches of humid cotton which is covered by a 2 or 3 inch layer of mechanics waste This is covered by gauze and then bandaged In dealing with uneven surfaces the important layer is the humid cotton In two or three days the cotton dries out and has a compact starchy feel It splints the graft into its bed as plaster of Paris will bind an extremity to the torso Wet cotton in contrast becomes too hard

Considerable literature has appeared recently in connection with the plasma thrombin fixation of grafts This has been discussed in Chapter 13 Sutures and Suturing It is an interesting adjunct to but no substitute for the old fashioned time

consuming suture With experience comes the knowledge that all but the full thickness graft will adhere rather well to the recipient site in from 4 to 6 hours with a pressure dressing The epidermic and thin split graft will stick to a recipient site within seconds, especially if pressed down with a twist exerted by a cold pack Ultimately the suture still remains as the only reliable form of fixation

INTERIM CARE OF FREE GRAFTS

After a free graft is mobilized it is often necessary to lay it to one side while re preparing the recipient site in some detail The graft should never be thrown care lessly on the instrument table or into a bowl of saline In the first instance it will dry and shrink very quickly or may even be accidentally discarded In the second in

Fig 125 Showing initial step in the waltzing of a supraclavicular tube en route to the nose Note freedom of trans ferred pedicle corked' into "Y" trap under mandible

Fig 126 Corking of arrowhead trap on forearm by abdominal tube Note eversion easy access to sutures and abundance of tissue surrounding pedi cle The last is possible because no tissue excision is necessary to make room for tube Closure of recipient site is also much easier eventually because of con servation of recipient edges as compared with other more commonly employed traps

stance (too commonly practiced by the occasional operator) the graft is emptied of its plasma and tissue juices This de prives it of the reserve sustenance it carries within its sole source of food supply and medium of osmotic balance necessary to survival until it is able to get additional tissue juices from the recipient site—a mat ter of 4 to 6 hours

Blood clots should be washed away before imbedding

The best interim care consists of folding the graft upon itself, rawside in, and laying it into some gauze which is humid with saline It is then rested in a safe place near the operating table Better yet, if the donor site does not have to be dressed immedi ately, the graft can be laid back rawside down and covered temporarily with dry gauze The assistant can then hold it in place and protect it against loss The physi-

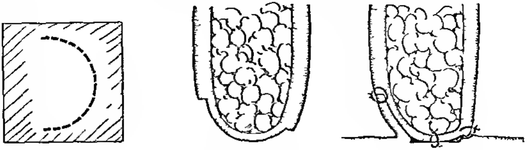


Fig 127A Claoue technic of tube trapping Trap incision for receiving closed pedicle decorticated of its epidermis before implantation and finally, imbedding of tube into recipient site

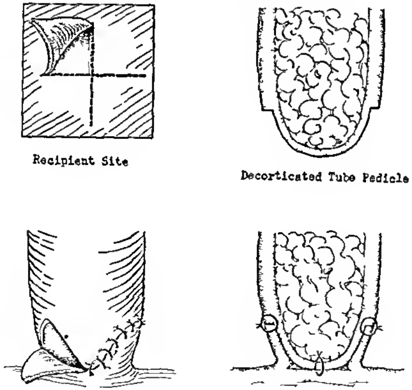


Fig 127B Claoue technic of tube trapping (*Continued*) Crucial tube trap for decorticated pedicle The decortication of the end of the tube is done on the principle that the immediate new circulation to the transferred peduncle comes mainly from the skin of the recipient site

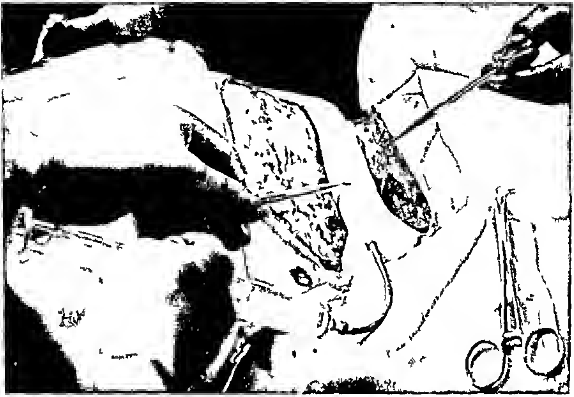


Fig 128 Catheterizing of tube for bleeding (*Top*) Bleeding point located in this instance is indicated by point of small scissors Glass syringe contains saline (*Bottom*) Catheter left in tube pending closure of donor site Latter is closed by shifting of abdominal flap under tube according to method of Bunnell in this case quite exadurated because of coincident removal of deep scar from left hypochrondrium

ologically ideal resting place obviously is its site of origin (Fig 43A)

Pedicles

Basic Fixation The fixation of pedicles is purely a matter of meticulous suturing Where a pedicle is applied to a flat or convex surface it may be sufficient to do no more than skin to skin approximation But in large flaps with considerable subcutaneous tissue it is good practice to place fine catgut sutures into the fatty tissue at strategic points of obvious tension to avoid subsequent retraction or shifting of the flap on its base

Where flaps are placed on uneven or concave surfaces it is usually necessary to employ subcutaneous sutures to hold the fatty tissue in the unequal depressions of the recipient site and thus avoid dead spaces seromas and spotty necrosis of the graft The presence of two or three fine plain cat

gut sutures under a thick flap aids rather than imperils its welfare

Complementary Fixation In cases where a pedicle is brought to a recipient site on a carrier' such as the arm or the leg, the mere approximation of the flap to the recipient site must be complimented by some form of fixation of the carrier and the recipient This may be done by additional secondary sutures, elastic bandage, adhesive, plaster of Paris, or orthopedic contrivance (Fig 133) This, as a matter of fact is often adequate protection and dispenses with actual immobilization by plaster splinting of the extremity to the torso

The difference between complementary fixation and splinting resides in the fact that the former is a means of safeguarding the physical welfare of a graft in transit, whereas splinting is a method of maintenance of anatomic relationship of displaced tissues

Since plastic cases are, for the most part, ambulatory, it is best that all complimentary fixation be as simple and as light as possible Hence, adhesive and elastic bandaging is usually the method of choice If given adequate consideration in design and meticulously applied, it usually is as reliable as the more cumbersome methods of plaster of Paris or orthopedic appliance

Supplementary Fixation Late or supplementary fixation of the graft in situ after final separation from the donor site, has been discussed in Chapter 19, 'Splints and Splinting This applies equally to free as well as pedicle grafts and is especially beneficial in the avoidance of wide, thick or otherwise obvious scars, as well as dis

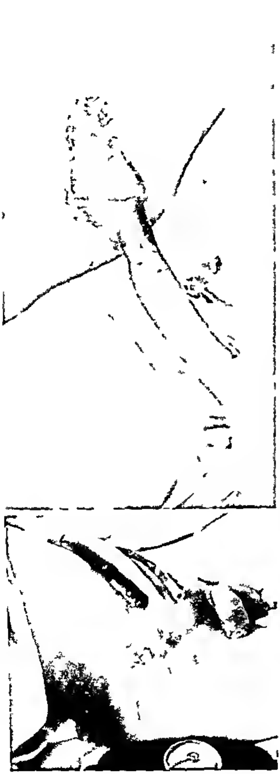


Fig 129 Some complications in pedicle tubing (*Top*) Gangrene of tube due to tugging on waltzed peduncle, resulting in hematoma under imbedded end of tube (*Bottom*) Extensive extravasation of blood in abdominal penile and scrotal tissues due to hemorrhage from inferior epigastric artery The tube survived without further complications The artery was undoubtedly perforated after completion of tube and during insertion of mattress tension sutures riding catheters as shown The blind insertion of sutures after tube is completed is risky

tortion of the recipient part through shrinkage or puckering of the graft The practice of supplementary fixation or functional splinting for a period of four or five days is inadequate It should continue through the period of complete organization of the graft or suture line This may take five or six weeks In the case of constantly moving parts such as the eyelids it may even necessitate fixation for several months

INDICATIONS FOR VARIOUS GRAFTS

Free Grafts

Free skin grafts of the less than full thickness variety may be said in general to be used almost solely for temporary resurfacing of parts or to make closed wounds out of open wounds

It has been found particularly from the tremendous experience accumulated in World War II that the epidermic graft serves best in all but rare exceptions as a kind of temporary biologic dressing Its uses in general may be stated succinctly by saying that it is indicated in any condition where the external loss of tissue is of such magnitude that early permanent dressing of the wound is imperative to the saving of life avoidance of infection collateral fibrosis and the conservation of a part It is functionally inadequate because minus the underlying derma it is inelastic does not wear shrinks discolors and adheres or freezes to structures it covers thus impeding their function

Fig 130 Free grafting of extensive deep wound of ankle via Waldron Esser technic The wax stent is pressed into the defect then cooled and removed retaining an exact impression of the wound The free graft is then basted about the stent rawside out and the ensemble is reinserted into the defect as shown This is then bandaged securely in place After from 7 to 8 days the basting sutures are cut the stent carefully removed the grafted defect irrigated and dried and the stent mold replaced for another week or more pending further plan of treatment

Split Grafts

Where the loss of tissue involves no more than the subcutaneous fatty layer a split graft can be used with reason and satisfaction It is functionally adequate in only selected cases and its general use for any tissue loss is not good surgical judgment

The split grafts are indicated where a permanent biologic covering is necessary as in third degree burns, following excision of ulcers or where surgical surface defects cannot be closed without tension

The thick split graft is especially valuable in lining cavities such as the nares the mouth the vagina or the eye socket It is especially fitted for the resurfacing of full thickness losses of the dorsum of the hand or in losses of the scalp (Fig 134) Here its reconstruction value is unquestioned

Full Thickness Grafts

The full thickness skin graft is indicated where ultimate good function and esthetic

Fig 131 (*Top*) Moth eaten appearance of split free graft the result of piecrusting which is sometimes used in the mistaken belief that all grafts must be drained (*Bottom*) Free-split grafted hands showing results obtainable without one perforation of grafts for drainage Such drainage is never necessary if the recipient site is thoroughly dry and if dressings are accurate Note bronzing of split grafts one of their main but occasional drawbacks

results are imperative as in facial resurfacing Where the loss involves more than the skin and subcutaneous tissue and provided that the remaining defect is not bare bone a full thickness graft is indicated and may be found to be permanently adequate (Fig 135)

Finally when skin grafting is unavoidable a graft should be used which reconstitutes as nearly as possible the loss in terms of anatomy

The important thing to remember is that a full thickness skin graft is permissible only when the recipient bed is free of scar granulation tissue infection tendon fascia bare bone or foreign bodies The ideal bed for such a graft is a fresh surgically created wound (see Recipient Site)

Flaps Tubed and Pillowed Pedicles

Grafts which originate as pedicles are always indicated where the tissue loss involves skin and subcutaneous fat where deep reconstruction of a part is germane to its functional integrity or where construction of a part is necessary (Fig 136) As has been indicated heretofore tissue adjacent to a defect in the form of a French or double peduncle flap is the ideal form of repair Barring this recourse must be had to the importation or transportation of tissue from distant parts of the body in the form of single-peduncle flaps or tubed pedicles Much has been written pro and con as to the choice of one or the other It is not always a matter of choice but where possible the choice method is the tubed or the pillowed pedicle This has been discussed at length earlier in the chapter

THE RECIPIENT SITE

No matter how well planned or conditioned a graft may be if the recipient bed is not adequately prepared the chances of ultimate success are small The recipient site is the soil the graft is the seed The quality of success depends upon the condition and the timbre of both

Categories of Recipient Beds

Recipient beds may be divided into four categories acute wounds, granulating surfaces, healed wounds and surgical or virgin beds An ideal site for grafting has the following criteria

1 Bacteriologically sterile
2 Good circulation througbout
3 No scar tissue, bare bone or tendon
4 No granulation tissue
5 No bleeding
6 No foreign bodies or edema
7 Must be stationary or subject to splinting
8 Must be accessible
9 Has good innervation
10 Patient in good general condition

The only ideal bed available with the above advantages is the surgically created bed or raw area sucb as a relaxing incision areas left after mobilization of pedicle flaps or decisions These are virgin beds Other things being equal, any type of graft has an excellent cbance of complete survival in such a bed

Next in order of desirability are sites healed by scar or scarred epithelium without a history of infection When these are completely divorced of all scar tissue, they come close to being virgin soil for grafting

Third in order are acute noninfected wounds caused by noncontaminated objects and containing no foreign bodies When adequately irrigated and dry, these can be *grafted immediately with good chances of* success Usually tbe only grafts indicated in these cases are the free grafts, preferably the split skin grafts These are applied on the principle of conversion of open into closed wounds

The granulating wound, even though clinically clean, is seldom bacteriologically sterile It bas only a pseudo blood supply and is tberefore suitable, as a rule, for coverage by only split or epidermic grafts Its desirability as a recipient site can be enhanced by the removal of the granulation tissue (see 'Preparation for Grafting")

Fig 132 Fiberglas as a proximal dressing (*Top*) Fiberglas gauze on *donor site for thick split graft (16 days* postoperative) The central irregular light area is the donor site The dark periphery is the result of accumulation of red blood cells and serum collected from the donor area by capillarity (*Bottom*) Fiberglas gauze peeled from re epithialized donor area (16 days postoperative) Note dry, clean appearance of area, covered by flakes of fibrin as is the light area on the gauze All tissue juices from the wound have been absorbed through mesh of fiberglas into overlying gauze dressings

Preparation for Grafting

Whatever the wound, it always should be thoroughly irrigated with saline before grafting Virgin beds need no other preparation except bemostasis Acute traumatic

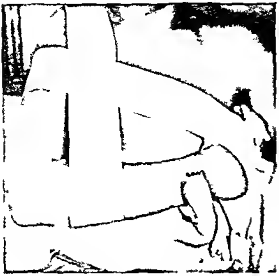


FIG 133 Complementary fixation A simple way of guaranteeing safety of tubal attachment to wrist without actual immobilization of the arm This permits a calculated amount of motion of shoulder elbow wrist and fingers

wounds may have to be debrided and inspected for foreign bodies If they are older than six hours and contaminated they are ipso facto out of graftable category until one is certain that no infection is present By that time they usually fall into the category of granulating wounds Notwithstanding if they are not too extensive they may be excised and immediately free grafted Split grafts of from 0 012 to 0 015 of an inch are the most suitable and reliable

Granulating wounds are ready to receive grafts only when the granulation is at least clinically clean flat pink nonexuberant and nonedematous (Fig 137) Where possible it is advantageous to remove the granulation tissue before grafting but it is not absolutely necessary if less than full thickness skin grafts are used In the latter case granulation tissue should be removed completely It may be a time-consuming procedure The usual objection to its removal is the profuse bleeding which may occur This can be markedly reduced if one takes the time to allocate carefully the line of cleavage between it and the underlying tissue and then dissect the former free with a dull knife in toto or in sheets The practice of scraping or curetting off granulation tissue is not a good one Having removed it the bed must be thoroughly dried and complete hemostasis must be insured No blood clots of any size must ever remain (For more detailed preoperative preparation of granulating beds see Chapter 20 for ideal granulating wounds see Plates 3 7 and 8)

POSTOPERATIVE CARE

FREE GRAFTS

Once a free graft has been applied and adequately dressed it should not be dis

FIG 134 Avulsion of scalp (subtotal) replaced by thick split free graft (3 months postoperative) Small area of superficial necrosis is due to a cigarette burn

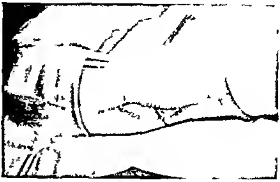
turbed for the minimal period necessary to its "take," or the establishment of circulatory communion between it and its bed This varies roughly in accordance with the thickness of the graft More specifically, it is parallel with the micro anatomic rather geometric thickness of the graft A safe working rule is to allow 15 hours for every 1/1,000 in in thickness of the graft before removing the dressings In other words, a graft of 0 010 in requires a period of 150 hours or about 6 5 days for the establish ment of safe circulatory communion with its bed No matter how thick a free graft may be, it should need nothing in excess of 250 hours for an adequate take Any graft over 0 020 in may be redressed after 250 hours

Thick grafts need subsequent snug dress ings for a period of time quite parallel with the foregoing formula This avoids late blis tering, spot necrosis, spontaneous epilation, conservation of hair growth and good color It is imperative for physiologic reasons Until a graft has attained adequate physi ologic organization, it is subject to all the exigencies of recently traumatized tissue, *i e*, at least 5 or 6 weeks for thick grafts

Condition of Graft and the Clinical Triad

There are certain rather dependable clini cal signs, a sort of reversible triad, which render quick information as to the condi tion of a graft, even before inspecting it These signs are pain odor temperature, or temperature odor pain The order of de velopment of the two sets of symptoms is determined by the primary cause of trouble in a graft The "P O T" as contrasted with the "T O P" means that the graft is suffering from primary necrosis, due to inadequate circulation, resulting in pain, then odor, from the decomposition of the necrotic material and finally temperature due to absorption and/or infection

In the "T O P" triad the graft is suffer ing from necrosis due to infection which



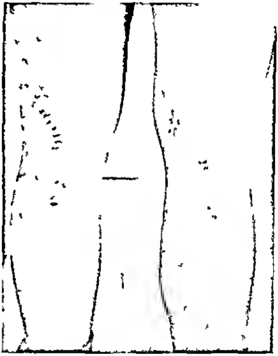


Fig 135 (*Top*) The ideal situation for a full thickness graft the raw fresh areas left after shifting of flaps In this instance a 'bridge' flap has been shifted anteriorly over the tibia, leaving a lat eral defect whose extremities could be closed by direct approximation without tension but the center had to be free grafted full thickness (*Bottom*) When ever feasible, flexor surfaces should be covered by full thickness grafts In this case bilateral "fiddlestring' scars were excised, tissues relaxed and defects free grafted A 'Z' plasty was not feasible Left leg 5 weeks postoperative, right leg, 5 months postoperative Note soft ness and good timbre of grafts Function was excellent

FIG 136A Synchronous application of two massive abdominal flaps one as a tubed island flap and the other as open flap (*Left*) Excision of healed bilateral gunshot wound of left elbow and donor site for simultaneous repair by abdominal tissue Flaps are outlined on left abdomen Arrows indicate direction of reflection of tissues Flap with arrow pointing upward is intended for external aspect of elbow Curved dash lines indicate calculated amount of the flap necessary to cover defects V shaped dotted line is the distance to which the vertical flap must be undermined to reach across antecubital space to lateral elbow defect Cross on abdomen is midline of body Inverted V shaped space at point of contact between flap extremities forms third flap to ablate part of donor site (*Right*) All flaps mobilized down to deep fascia with extremity in trial position for flap approximation Note undermining of inferior V flap to be advanced into donor area Also note deep tissue derangement due to compound comminuted condition of elbow and proximal one third of forearm

sets up the clinical picture by a rise in temperature (at first local and eventually general) instead of pain When a patient s first complaint is pain on the third to the fifth day in the grafted area and particularly when he is inclined to point with a finger to the painful spot under the dressings the probability is that there is trouble with the graft due to necrosis resulting from disturbed or originally poor apposition and hence to inadequate circulation If on the other hand the patient has been developing a temperature usually after the second to the fourth day and this is paralleled or more often succeeded by pain the destruction of the graft is due to infection The pain in the infected case is of a more gradual onset intermittent character and more severe whereas the pain of necrosis is of a more immediate development rather continuous and aching in character

Unless one of these triads is present one never should worry about the graft or allow

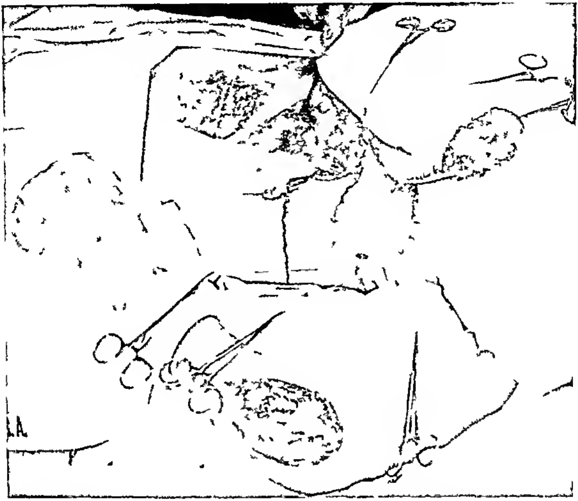


FIG 136B Synchronous application of two massive abdominal flaps (*Continued*) Flap destined for outer aspect of elbow is shown tubed to a point leaving island of tissue consistent with size of lateral defect Inverted V flap from side of abdomen has been advanced into donor site Raw surface under tubed flap has been free grafted from secondary donor site along umbilicus as shown Large flap intended for medial arm defect is folded back on itself in direction of secondary (free graft) donor site

curiosity to precipitate adversity by peeking under dressings

PEDICLES

The postoperative care of pedicle cases must be divided into two phases particularly during the stage of carrier transfer they are the care of the patient and the care of the donor and recipient parts

The patient who has a defect necessitating carrier transfer of tissue is usually one who has been ill for quite some time if not actually bedridden for many weeks or months He is sometimes afflicted with certain concomitants of invalidism such as anemia hypoproteinemia poor circulation vasomotor disturbance and psychological problems All these must be attended to lest the overdiligent care of the grafted part eventuate in neglect of the individual This may lead to delayed healing joint complications or a psychosomatic breakdown

The particular care of the graft is comparatively simple Reduced to a common

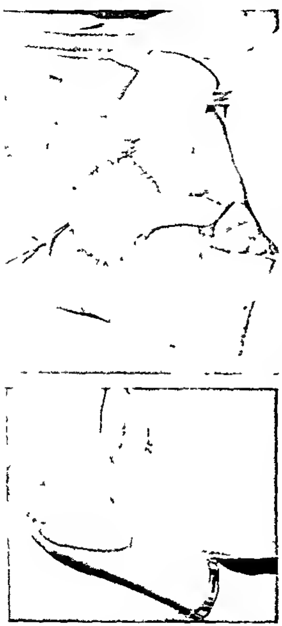


FIG 136C Synchronous application of two massive abdominal flaps (*Continued*) (*Top*) Both medial and tubed lateral flaps have been sutured into position Medial flap under elbow is so closely fitted it could not be shown in this photograph (*Bottom*) Results of grafting of medial defect Patient's back of left hand laid against sacral region to expose medial aspect of elbow Free-grafted part of donor site partially showing on chest Flap grafts can be re elevated later for bone grafting of elbow

denominator, it implies maintenance of original splinting, avoidance of infection, aspetic management of the donor and recipient areas, infrequent dressings, treatment of complications such as hematomas and abstinence from inquisitive interference with dressings (For additional information as to regular periodic inspections, see Chapter 14, "Postoperative Management")

DEFERRED SKIN GRAFTS

The notion of skin storage as a good source of material in emergencies has plagued investigators for a 150 years The idea was again revived during World War II, because of the large percentage of casualties due to loss of skin consequent upon extensive burns This was unavoidable in a war based on the use of highly inflammable material A number of individual efforts were made to create so-called "tissue banks" of one type or another

HISTORICAL

According to J P Webster, Baronio in 1804 successfully replaced mobilized full thickness skin grafts in sheep after an interval of one hour According to J S Davis, Hodges in 1871 tried grafting of preserved dried skin No mention is made of any success Ljundgren succeeded in grafting pieces of skin kept in sterile ascitic fluid up to three months, it is claimed

Wentscher, in 1903, was the first to transplant successfully (?) skin autografts after 14 days of refrigeration Brown and McDowell, in 1943, record the following

> In one case a successful full thickness graft of the neck had been stored in an ice box for 48 hours, as far as is known, this was the first clinical instance of the use of the procedure One can conjecture all sorts of storage plans and tissue culture plans for grafts, to be used in war time, but final success has not been attained *

Jerome P Webster is the most recent ex-

* Brown J B., and McDowell F Skin Grafting of Burns Philadelphia Lippincott, 1943, p 169

FIG 137 (*Left*) A suitable granulating wound Note flat clean granulating surface The large defect is the point of exit of a gunshot wound whose point of entry is seen in the subdeltoid region (*Right*) Split graft resurfacing of pending reconstruction of arm (2 weeks postoperative) (See Fig 25 for flap reconstruction and geometrics of method)

ponent of the use of deferred skin grafts His first attempt at the transfer of a refrigerated graft was made in 1932 The graft was four days old when applied and ' proved successful "

REFRIGERATED SKIN

Methods The skin, after being mobilized, is folded upon its raw surface According to Webster's method it is then wrapped in pliofilm and again in xeroform or petrolatum gauze

I prefer to place the folded skin between two snugly fitting appropriate watch glasses which are sealed with paraffin This is then placed in a large sterile Petri dish which is hermetically sealed with Scotch tape The dish is then placed in an ordinary refrigerator When the graft is needed, the dish is removed by the nurse, the Scotch tape is peeled off, the cover is lifted, and the watch glasses containing the graft are lifted out with sterile forceps The graft may then be applied in the conventional manner

Webster reports successful takes up to 21 days of refrigeration This is probably the contemporary record Brown and Mc Dowell's graft was stored for only 48 hours My own experiences do not reach beyond the sixth day In none of these have I had complete anatomicophysiologic success

Indications

1 Extensively burnt children, usually poor risks

2 Poor surgical risks in general

3 Extensively burnt adults in whom mo bilization followed by immediate grafting is impossible

4 In patients with multiple burns where more skin is mobilized than is needed for any one burn

5 Patients with extensive abdominal hernias, where an otherwise prolonged and complicated procedure is thus divided into two less taxing stages

6 Homograft banks' for anticipated emergencies as in war

7 Experimental purposes

TATTOOING OF GRAFTS

One of the pre eminent features sometimes listed as a drawback in free grafting is that the grafts fail to attain the color of the recipient skin This failure of adequate pigmentation may result in an area which is either too light or too dark, as com pared with the skin surrounding the recon struction The grafted area may remain permanently obvious

Therefore about 1933 Vilray P Blair conceived the idea of color tattooing of grafts to match them to their environment This notion was taken up by one of his assistants, Gertrude Hance, and was de veloped into an interesting technical ad junct to plastic surgery

Basically the idea is not entirely new, since tattooing of the skin dates back approximately 2 000 or 3,000 years B C Notwithstanding the reasons for tattooing at that time were different from those suggested by Blair

Tattooing is the act of insinuating mineral pigment into the skin by pricking the skin and depositing the pigment with needles The needle may be electrical or manual Ideally, the pigments must be essentially nonirritating, stable to the effects of metabolic processes, nonpoisonous and relatively unchangeable by time and light Some of the pigments most frequently em ployed for tattooing of grafts are barium sulfate, manganese, carbon, alizarin and other of the earthy metallic oxides

TECHNIC (HANCE)

The area to be tattooed should be prepared aseptically as for any other operation All instruments employed should be sterilized, and the materials used for pigmenta tion should be autoclaved Analgesia or anesthesia of some type is advisable

After thorough mixing of the necessary basic pigments to a creamy state with saline, it is spread partially over the area to be tattooed It is good practice when mak ing up the mixture to have it a shade lighter than the surrounding skin, because if the end result is not concentrated enough the graft can always be retattooed If the tattoo ing turns out too dark, it is impossible later to bleach it

Any simple tattooing needle or any one of the electrical contrivances on the market may be used for the deposition of the pigment into the graft This is usually done to a depth of at least half the thickness of the skin

Following the tattooing the skin usually appears a kind of deathly color and it eventually shows signs of inflammation lasting for ten days or more Then a period of epilation or peeling of the skin occurs, dur ing which time it is well to apply some type of bland ointment

It is very difficult to get a proper and even color match with the first attempt It is therefore often necessary to retattoo areas, either to darken the graft or to obliterate small patches which may have

been missed during the first treatment

The tattooing of skin grafts or flaps should not be done prior to the lapse of about a year postoperatively The immediate benefits of tattooing are obvious What the ultimate results and the possible consequences may be only time and experience will tell The dangers seem to be remote but neoplasia has been known to occur in tattoos

Without question this is a welcome technical addition to skin grafting particularly as concerns the mimicking of such parts as the vermilion borders of the lips It is impossible at times to secure enough normal vermilion for a newly constructed lip without which the latter remains an obvious esthetic defect

BIBLIOGRAPHY

Alglave P Presse méd July 23 1817 p 419

Aufricht G Evaluation of pedicle flaps versus skin grafts in reconstruction of surface defects and scar contractures of the chin cheeks and neck Surgery 15 5 84 1944

Bainbridge W S Intra abdominal plastic repair J Internat Coll Surgeons 9 542 1946

Barber C G Skin transplantation by injection Its effect on healing of granulating wounds Arch Surg 43 21 1941

Barker D E Anaphylaxis and the homotransplantation of skin Plast & Reconstruct Surg 3 34 1948

Baxter H The effect of penicillin and streptomycin applied locally on the take of skin grafts Plast & Reconstruct Surg 1 322 1946

Beck C Surg Gynec & Obst March 1918 p 259

Billig H E Muscle reinnervation J Internat Coll Surgeons 7 457-461 1944

Brenizer A G Skin and fascia grafting Am J Surg 47 265 1940

Brown J B The closure of surface defects with free skin grafts and with pedicle flaps Surg Gynec & Obst 84 862 865 1947

——— Homografting of skin with report of success in identical twins Surgery 1 558 1937

Brown J B and Byars L T Spontaneous and surgical covering of raw surfaces Journal Lancet 60 503 1940

Brown J B and Cannon B Full thickness skin grafts from the neck for function and color in eyelid and face repairs Ann Surg 121 639 642 1945

——— Composite free grafts of two surfaces of skin and cartilage from the ear Ann Surg 124 1101 110 1946

Brown J B and McDowell F Epithelial healing and the transplantation of skin Ann Surg 115 1166 11 9 1942

——— Persistence of function of skin grafts through long periods of growth Surg Gynec & Obst 72 848 1941

Butcher E O Fate and Activity of Autografts and Hemografts of Skin in White Rats (Summary)

Byars L T Free full thickness skin grafts Principles involved and technique of application Surg Gynec & Obst 75 8 1942

——— Tattooing of free skin grafts and pedicle flaps Ann Surg 121 644 1945

Byars L T McDowell F and Brown J B Fundamental principles of skin grafting The Interne Sept 1946 pp 588 593

Cannaday J E Use of cutis graft material in the treatment of trauma and its results Am J Surg 74 32 1947

——— The application of the cutis graft to various types of reconstructive surgery J Internat Coll Surgeons 9 655 664 1946

Claoue C Technique de transport par inclusion dermique ou procede de la sangsue (methode de l auteur) Chirurgie reparatrice des pertes de substances par lambeaux cutanes tubules Monde med Paris 7 3 11 1940

Cole W H and Greeley P W Util zation of pedicle skin grafts in correction of cicatricial anal stenosis Surgery 12 349 1942

Converse J M and Duchet G Successful homologous skin grafting in a war burn using an identical twin as donor Plast & Reconstruc Surg 2 342 344 1947

Conway H Sweating function of transplanted skin Surg Gynec & Obst 69 756 1939

DaCosta J C Modern Surgery ed 3 Philadelphia Saunders 1903 p 922

Davis J S Surg Gynec & Obst Nov 1907 p 554 Ann. Surg March 1909 p 416 Bull Johns Hopkins Hosp 15 307 Ann Surg Dec 1910 p 21 Boston Med & Surg Jour June 6 and 13 1912 J A M A Sept 19 1914 p 985 Surg Gynec & Obst July 1917 p 1 J A M A Sept 22 1917 p 907 J A M A Dec 22 1917 p 2085

——— Plastic Surgery Its Princ ples and Practice Philadelphia Blakiston 1919

——— The small deep graft its relationship to the true reverdin graft Ann Surg 89 902 1929

——— The use of small deep grafts in the

repair of surface defects, Am J Surg 47 280-298, 1940

Davis, J S, and Kitlowsky, E A Regeneration of nerves in skin grafts and skin flaps, Am J Surg 24 501, 1934

Davis, J S, and Traut, H F Origin and development of the blood supply of whole thickness skin grafts, Ann Surg 82 871, 1925

Davis, Loyal The return of sensation to transplanted skin Surg, Gynec & Obst 59 553, 1934

Douglas, B and Millikan, G A The blood circulation in pedicle flaps Preliminary studies on a photo electric test for determining its efficiency Plast & Reconstruct Surg 2 348, 1947

Dragstedt L R A modified sieve graft, Surg, Gynec & Obst 65 104 1937

Esser J F S Neue Wege fur Chirurgische Plastiken durch Heranziebung der Zahnaerztlichen Technik Beitr z klin Chir 103 547, 1916

——— New York Med Jour, Aug 11, 1917, p 264 Ann Surg, March 1917, p 297

——— Use of the praeputium skin in "structive" surgery, J Internat Coll Surgeons 7 469 470 1944

Evans J G Sano tissue glue skin grafting J Internat Coll Surgeons 8 424 426 1945

Finney J M T Ann Surg July, 1909, p 324

Gillies H D Practical uses of the tubed pedicle flap Am J Surg (N S) 43 201 214, 1939

——— Plastic Surgery of the Face Oxford Med Pub 1920

Gordon S and Warren R F Reflex vasodilatation in tubed pedicle skin grafts, Ann Surg 123 435 446 1946

Greeley P W Skin Grafts Surg Clinics of North America Chicago Number, Philadelphia and London Saunders 1948

Halsted W S Bull Johns Hopkins Hosp, 1897, p 25 Tr Am S A 3 287 1912

Hance G Brown, J B, Byars, L T, and McDowell F Color matching of skin grafts and flaps with permanent pigment injection, Surg Gynec & Obst 79 624, 1944

Hanrahan E M The use of a migrated skin flap for both lining and covering of an artificial antethoracic esophagus Plast & Reconstruct Surg 2 424 1947

Ivy R H Principles of skin grafting, J Internat Coll Surgeons 8 520 524, 1945

——— Principles of skin grafting, Clinics 3 1623-1640 1945

Jeremiah B S Squamous cell carcinoma development of donor area following removal of a split thickness skin graft, Plast & Reconstruct Surg 3 718, 1948

Kitlowski, E A Pedicle Skin flaps Transactions, 13th Ann Meet, Am Soc of Plastic and Reconstructive Surg, New Orleans, La, Oct, 1944

Koch, S L The transplantation of skin and subcutaneous tissue to the hand, Surg, Gynec & Obst 72 157 177, 1941

Krause Verbandl der deutsch Gesellsch f Chir 22 Kong, 1893 Arch f klin Chir 46 177, 1893 Sammlung klin Vortrage, No 143, 1896 Centralbl f Chir 23 267, 1896

Lexer, E Weiderherstellungs Chirurgie Leipzig, Barth, 1920, p 360

Longmire, W P, Stone, H B, Daniel, A S, and Goon, C D Report of clinical experiences with homografts, Plast & Reconstruct Surg 2 419, 1947

McEvitt, W G Experiences with fibrin fixation methods of skin grafting A clinical evaluation J Michigan M Soc 44 1347, 1945

Macomber, D W, and Wynn, S K Practical points in Wolfe graft technique, Surgery 21 86, 1947

Macomber, W B, and Patton, H S The split thickness graft, a useful adjunct in tube pedicle preparation, Surg, Gynec & Obst 84 97, 1947

Macomber, W B, and Rubin L R Tube pedicle complications in repair of massive tissue defects, Plast & Reconstruct Surg 2 10 20 1947

Mair, G B Use of whole skin grafts as a substitute for fascial sutures in the treatment of hernias Preliminary report, Am J Surg (N S) 69 352 365, 1945

Maltz, M New method of tube pedicle skin grafting, Am J Surg (N S) 43 116-222, 1939

Mandl, F, and Rabinovici N Experiments with "cuto omentopexy" and skin homotransplantation, J Internat Coll Surgeons 9 525-530, 1946

Marcks, K M The use of implantation grafts in the healing of infected ulcers, Am J Surg (N S) 51 351-360, 1941

Matthews, D N The Surgery of Repair, Blackwell Scientif Pub, Ltd, 1943

May, Hans Methods and Advances in Skin Grafting (Surgical Clinics of North America, Philadelphia Number), Philadelphia, Saunders, 1947, pp 1461-1465

——— A simple device to test and to improve the circulation in a pedicle flap, Surgery 21. 582, 1947

May, Hans, and Spann, R G Cutis Grafts for

Repair of Incisional and Recurrent Hernias Surg Clin of North America N Y Number Philadelphia Saunders 1948 pp 517 524
Mayo C Ann Surg Sept, 1914, p 371
Mixter Boston Med & Surg Jour 124 163, 1891
O Connor G B Establishment of cartilage depots for military and civilian use, Am J Surg (N S) 58 313 314, 1942
Owens, Neal Simplified method of rotating skin and mucous membrane flaps for complete reconstruction of the lower lip Surgery 15 196 206 1944
Padgett E C Indications for determination of the Thickness for 'Split Skin Grafts Trans 13th Ann Meet Am Soc of Plastic & Reconstructive Surg New Orleans, La, Oct 1944
—— Is iso skin grafting practicable? South M J 25 No 9 1932
—— Indications for determination of the thickness for split skin grafts Am J Surg 72 683, 1946
—— Calibrated intermediate skin grafts Surg Gynec & Obst 69 779 1939
Payr P Centralbl f Chir Sept 1908 p 1065
Peer, L A Buried grafts to repair depressions J M Soc New Jersey, Oct 1938 p 601
Pick J F A critique of the free skin graft, South M J 38 No 12, 1945
Poth E J A technic of skin grafting Surg Gynec & Obst 75 779 1942
Rabinovici N The fate of skin homotransplants performed on previously x rayed rats, Plast & Reconstruct Surg 2 413 1947
Reese, J D Dermatape A new method for the management of split skin grafts Plast & Reconstruct Surg 1 No 1, 1946
Reverdin J L Bull de la Societe imperiale de chir Paris Dec 8 and 15, 1869, pp 493 and 511 Med Times & Gaz 2 43 (Editorial) 1870 Boston Med & Surg Jour, 4 196 (Editorial), 1870 Gaz des Hop 1870, p 6 Gaz med. de Paris 24 554, 1870 Bull gén de therap 82 71 1872 Arch gen de méd, 19 276, 555, 703, 1872
—— Arch gen de med, 19 703 1872
Sano, M E, Holland, C A, and Babcock, W W The Use of the Coagulum Contact Method in Surgery Surg Clin of North America, 23 1673 1695 (1943)
Schmieden, V Centralbl f Chir, Bd 35 153, 1908
Shaw, D T, and Payne, R L, Jr One stage tubed abdominal flaps Single pedicle tubes, Surg, Gynec & Obst 83 205, 1946
Shawan, H K Principle of blood grouping applied to skin grafting, Am J M Sc 157 503, 1919
Sheehan, J E Plasma fixation of skin grafts, Am J Surg (N S) 65 74, 1944
—— Plasma fixation of skin grafts critical analysis of technic Plast & Reconstruct Surg 1 317, 1946
Sheehan, J E, and Jenney, J Continuous epithelisation on large denuded areas, Lancet Jan 26, 1946, p 123
Smith F Pressure bags for skin grafting Surg Gynec & Obst 43 99 1926
Stark R B Pre operatively applied mated plaster of paris casts as an aid in the migration of open pedicle cross leg flaps, Plast & Reconstruct Surg 2 433-438 1947
—— Blood supply of cross leg pedicle flaps Plast & Reconstruct Surg 3 694 1948
Stefanoff D N Obtaining extremely large skin grafts Plast & Reconstruct Surg 3 745 1948
Straith C L, and McEvitt W G Total avulsion of the scalp A review of the problem with presentation of a case of skin graft in which thrombin plasma fixation was used Occup Med 1 451, 1946
Swenson S A and Harkins H N Cutis grafts Application of the dermatome flap method Its use in a case of recurrent incisional hernia Arch Surg 47 564 1943
Thiersch, K Ueber Hautverpflanzung Verhandl d deutsch Gesellsch f Chir 15 17 1886
—— Verhandl d deut Gesellsch f Chir 1874 p 69, Arch f klin Chir 17 318, 1874 Centralbl f Chir 1876 p 504, Verhandl d deut Gesellsch f Chir xv Kongress, 1886 p 17, Centralbl f Chir 1886 Beilage p 1 Centralbl f Chir 1886, Nr 24 Verhandl d deut Gesellsch f Chir 1888 pp 66 68
Tidrick, R T Fibrin fixation of skin transplants, Surgery 15 90 95, 1944
Torrance Phila Med Jour July 13 1901, p 75
Veal J R, Klepser, R G and DeVito M P The preparation of superficial wounds for skin grafting by the local use of sulfanilamide and sulfanilamide allantoin ointment Am J Surg (N S) 54 716 1941
Warren J M Boston Med & Surg Jour, March 8, 1837, p 5, Boston Med & Surg Jour, June 3, 1840, p 16, Boston Med & Surg Jour, March 1, 1843, p 68
Webster J P Symposium on Reparative Surgery Film Cemented Skin Grafts Excision and Handling of Split-Thickness Grafts (Surgical Clinics of North America New York Number), Philadelphia, Saunders, 1944, pp 251-280
—— Refrigeration skin grafts, Ann Surg 120 437-449, 1944

Wilmoth, C L The tubed pedicle graft in facial reconstruction, Am J Surg (N S) 53 300 305, 1941
Wolfe J R A new method of performing plastic operations Brit Med Jour, Sept 18, 1875, p 360, Glasgow Med Jour, April 1876, Med Times & Gaz June 3, 1876
Young F Skin graft fixation by plasma-thrombin adhesion, Ann Surg 120 450 462, 1944
Young, F, and Favata B V The fixation of skin grafts by thrombin plasma adhesion, Surgery 15 378, 1944
Zeno, L Free skin graft—immobilization with plaster, Plast & Reconstruct Surg 2 549 556, 1947

17

Grafts Other Than Skin

MUCOSAL GRAFTS

Types

Mucosal grafts are of two types the free and the pedicle grafts The former are rarely used and have, as a matter of fact, only two specific indications, the reconstitution of the vermilion lining of the lips and coverage of the glans penis (see Chap 31)

The pedicle graft in the form of a flap is frequently employed in situ in reconstructions within the oral cavity, the nasopharynx and occasionally within the nose, the urinary bladder or the rectum There is so little mucosa available for free transplantation that in other sites than the vermilion of the lip split skin grafts constitute an adequate and acceptable substitute

Indications for Use

As stated heretofore, the only imperative indication for mucous membrane grafts is the vermilion border of the lips When this is not possible, which is rare, it is far better to tattoo the new lip than to use a skin graft which never assumes the appearance and the qualities of mucous membrane This is true of skin grafts when used intraorally

Methods of Mobilization

When a free graft of mucous membrane becomes imperative, the mucosa is mobilized in the same manner as a full thickness skin graft (Fig 138) Split grafts of mucous membrane are inadequate because, in due course of time, they have a tendency to lose the qualities peculiar to the tissue Pedicle grafts of mucosa are comparable to small pedicles of full-thickness skin Because they are used within the confines of the oral cavity they must be designed very accurately so as not to lead to derangement of the lining of the mouth

The mucosa is far more elastic than skin and because of this quality there is an abundance of the tissue present in the oral cavity for the average reconstruction necessary A proper working knowledge of intraoral reconstruction via pedicled flaps of mucosa results in many very gratifying procedures These are comparatively simple operations whereas if skin grafts are employed, the operations become much more involved and usually imply complex intraoral splints

Methods of Fixation

These are of the same order as those which apply to skin grafts and skin pedicles

FAT GRAFTS

Types

Fat grafts may be divided into three types free grafts, pedicle grafts and tubal grafts (Fig 242B)

Methods of Mobilization

The usual practice in mobilizing a fat graft is to make a random incision through the skin until the subcutaneous tissue is reached, when the desired amount of fat is excised with more or less abandon as to size and shape The piece of fat is then cut up to serve the physical requirements of the case This results in a piece of tissue whose edges consist of ruptured fatty lobules Such

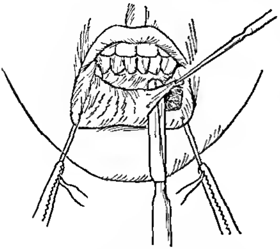


FIG 138 Mobilization of mucous membrane of lower lip as a free graft When this method is employed, as near the full thickness of the lining should be taken as possible Free-hand dissection may be used and in some lips is easier

free fat is irritating to other tissues This is one of the basic reasons for the notorious failure of fat grafts

The usual experience with a fat graft is that after its imbedding at least one third of it will necrose or liquefy It is then absorbed or extruded

It has been my practice in mobilizing a free or pedicle fat graft to incise the skin carefully so as not to damage the superficial layer of the superficial fascia found immediately under the derma When that has been reached the skin is as carefully undermined until distinct lobes of fat can be identified Since the fascial investments of the fatty lobes carry the blood supply, it seems logical practice borne out by certain clinical experiences, to dissect out lobes of fat rather than blocks of fat This is a procedure both difficult and painstaking Insofar as the success of grafts depends upon early establishment of communion between the blood vessel walls found in the graft and those of the recipient bed, the less injury the blood vessel walls of the graft sustain during the mobilization of the graft the better is the chance for survival In other words, the physiologic method of fatty transplantation should be based upon the transfer of entire fat lobes rather than oily and seeping blocks of fatty tissue

When a block of subcutaneous tissue is transplanted with extruded raw fat around its periphery, the latter acts as a biologic foreign body separating the invested fat graft from its bed This accumulation of foreign material embarrasses the early communion between the blood vessels of the investments of the fatty graft and the bed Such a fat graft differs little from a macerated muscle or traumatized skin graft

The same applies to the mobilization of pedicle flaps of subcutaneous tissue The delicate line of cleavage between lobes must be identified and followed as far as possible in designing a flap so that when the flap is completely mobilized it resembles in shape, external appearance and color a young fibrolipoma rather than a piece of raw yellow fat This type of flap, when rotated, advanced or transposed, will maintain its integrity far better than one which has been cut phlegmatically The amount of liquefaction, necrosis or absorption of this type of fat graft will be found to be much less than that experienced in the conventional type of mobilization (Fig 139) The ideal free fat graft consists of one lobe of fatty tissue with unbroken fascial investment The best pedicle fat graft is one possessing, where possible, an artery of supply and so mobilized that all the peripheral lobes are fully invested by fascial covering and are individually exposed to the blood supply of the recipient site In other words, where there is no central blood supply to the interior of the pedicle, the pedicle should consist of one layer of fatty lobes, otherwise those in the interior of the pedicle will undergo liquefaction necrosis not unlike that of the center of a thick tendon graft and will lead to complete loss of the graft

In any case, the principle involved is to transfer fat in terms of anatomic units and

therefore physiologically adequate tissue The occasionally suggested proposition of "injecting" macerated or liquefied fat for shallow depressions is contrary to principle Wakeley has recently suggested the injection of sterile liquid fat via the hypodermic needle The end results of such practice are not available but it is safe to say that since it is basically unphysiologic the method is destined to failure Liquefied fat, in the same manner as traumatized fat, is irritating immediately acts as a biologic foreign body and leads to fibrosis

Where the meticulous mobilization of fat grafts is not feasible as described it is still possible to carry out the principle by carefully debriding the random block of fat of its outer ruptured lobes This is done gently until a unit of fascia enclosed fat, faintly pinkish in color, results If any tags of free fat are allowed upon the graft they will, as stated, liquefy and act as foreign material inimical to early contact of the fascial investments with the bed

A third method of mobilizing fat grafts has been employed by the author with gratifying results, and consists of what may be called the tubed fat graft Advantage is taken of the transportability of subcutaneous tissue within the conventional tubed pedicle When the tube is brought into the vicinity of the defect, its outer two thirds or more of skin thickness is dissected off ("peeled") freehand, the tube is then opened in the usual manner and the fat with a thin covering of derma is tunnelled into the defect, fattyside out, and left attached on one of its peduncles (Fig 242B) After the lapse of 10 or 12 days, the peduncle or peduncles, as the case may be, and which are still external to the defect, are severed, "peeled" and buried in order to augment the repair

Indications for Use

Fat grafts, either in their free, pedicled or tubed form, are conventionally used for filling in depressions, padding of joints in place

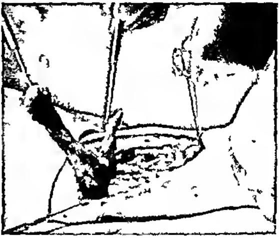


Fig 139 Pedicles of fat in the ablation of deep tissue voids Note smooth, fascia invested pedicles Large fat flap mobilized from posteromedial region of leg Its distal extremity is destined for deep excavation in tibia indicated by hemostat

of bursa loss due to trauma coverage of tendons, nerves or bones to prevent adhesions and the filling in of dead space as an interim procedure in soft tissue revision pending the ingrafting of bone or cartilage (Fig 139)

Methods of Fixation

Free grafts of fat are usually insinuated into a geometrically prepared subcutaneous bed after primary revision of the covering tissue has been accomplished Hence, the fixation of such grafts is accomplished primarily by the design of the pocket into which the graft is placed To avoid retraction, shrinkage, curling or displacement of such grafts, it is wise that they be anchored into position by so called guiding or lead sutures (Fig 140) Two sutures are insinuated into the opposite poles of a fat graft, one of which is used to lead the graft into the prepared bed and the other to guide and secure it to the proximal and internal portion of the bed

Pedicle flaps of fat should be fixed to a minimal extent in their beds with the finest, plain catgut This is particularly indicated where flaps of subcutaneous tissue are used

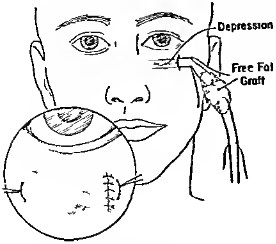


FIG 140 Technic of implanting of free fat graft Buttonhole incision is made to one side of the depression, the skin over depression is undermined lead needles on the graft are insinuated and brought out alongside of the nose These are pulled through thus placing fat graft into the depression The suture is tied outside of skin as shown in the inset Follow up needles anchor graft under buttonhole incision and the latter is closed as shown in the inset

to fill in deep depressions following excision of extensive wounds If this is not done the flap has a tendency to twist, roll or retract out of the depths of the wound and so fail to subserve its primary function of obliteration of dead space

The fixation of the tubal fat graft is accomplished in one of two ways If the accessibility to the bed is sufficient, subcutaneous plain catgut anchorage may be possible Ordinarily the fat being tunnelled into the defect must be kept in its spread out position by picking up its edges in strategic spots with transcutaneous sutures of dermal or horsehair These may be removed in from five to seven days

FASCIAL GRAFTS

Types

Fascial grafts are usually ribbons of tissue obtained from the femoral or the rectus fascia and may be either free or pedicled

Methods of Mobilization

When fascia lata is used, the graft may be obtained by making an incision down to the fascia to a length consistent with the strip to be excised Or a buttonhole incision may be made through which a fasciatome is inserted After raising a small, short pedicle of fascia, the latter is inserted or attached into the fasciatome and then by forcing the instrument upward toward the trochanter any desired length of strip may be removed If more than one is necessary several strips may be removed

Although the fasciotome method has the advantage of avoiding a long skin incision it has certain disadvantages It may result in a hematoma This may be due to an injury to the vessels of the deep layer of the subcutaneous tissue or at times to the femoral musculature Another disadvantage lies in the fact that following removal of fascia by an instrument there is no way in which to suture the resultant surgical defect Herniation of the muscles of the thigh may result, leading to adhesion to the derma with consequent pain and dysfunction In this connection small defects in the fascia lata usually cause more trouble than large ones Consequently, if such a complication arises, unless the defect in the fascia can be easily repaired, it is far better to enlarge it, thus avoiding constriction of a small part of the muscle

Indications for Use

Fascial grafts may be employed to fill in small depressions, as free grafts for ablating comparatively small defects in other fascias, to repair extensive hernial defects, as sutures, as slings for paralyzed muscles (viz, fascial paralysis), as a means of supporting muscle herniations, in the effacement of retrotarsal atrophy and for internal defects

Methods of Fixation

The method of fixation of a fascial graft is somewhat dependent upon the nature of

the tissue to which the fascia is opposed If fascia is to be sutured to fascia, either silk, fascia itself or chromic catgut may be used If it is to be sutured to muscle it is better to use cotton Where fascia is to be opposed to bone it is best to drill a tunnel through the latter, adequate for the passage of one end of the fascial strip The strip is then folded back on itself, and the end is sutured to the main ribbon with cotton or silk

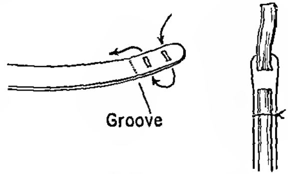


FIG 142 Method of threading of Pick s fascia guide

POSTOPERATIVE CARE

Where fascia is used as a free graft, or as a sling, and particularly where it is sutured to other tissues than to itself, it is to be remembered that fascia is slow in making permanent and reliable communion with other tissues It is, therefore advisable to splint the part for a period of at least 16 days Secondly in some patients fascia may and does produce considerable local foreign body reaction with infiltration Hence, it is advisable for the first three or four postoperative days to keep pressure dressings over the area to avoid excessive lymph infiltration, swelling and possible disruption of the repair

Norman L Cutler in a report on the postmortem microscopic examination of fascia grafts—used in a patient three and one half months prior to death resulting from an automobile accident—for the effacement of *retrotarsal atrophy, states*

Sections through the fascia lata implant in the upper left eyelid show viable fascia There is no necrosis There are however, foci of granulomatous inflammation, characterized by exudation of lymphocytes proliferation of histiocytes, and numerous foreign body type giant cells There is also deposition of crystalline pigment presumably hematogenous in origin The fascia gives evidence of a foreign body reaction *

FIG 141 Pick s fascia guide The ribbon of tissue (fascia or derma) is threaded through the first (distal) slit and then through the second The end is then tied by a suture to the groove just proximal to the slits In actual practice, the tying is seldom necessary Due to flatness of the instrument, there is little chance for the fascia to twist or 'string' unless the instrument is deliberately rotated Length of instrument is 10 inches

The stringy' cutaneous evidences of fascial implants, particularly in the face are usually due to the fact that during the insertion of the fascial slings the latter have been twisted and not placed in the flat ribbonlike form in which they were mobilized This should always be guarded against in order to avoid such esthetic defacement and can, to a great degree, be avoided by care and the use of proper instruments (Figs 141 and 142)

MYO GRAFTS

TYPES

The nature of the muscle fiber mitigates against the use of it as a free graft Strictly speaking, muscle can be used only as a pedicle flap, and then to a limited degree On the other hand, it can be transplanted in toto (pedicled from its origin) with greater safety than in part as a pedicle

Prudente of Brazil describes a method of so called "Free Muscle Transplantation in the Restoration of Lips and Cheeks "†

* Cutler, Norman L Am J Ophth 29 176 179, 1946

† Prudente A J Internat Coll. Surgeons 7 312, 1944

The method consists essentially of what in the present text is referred to as "tubal transfer" in its reference to the transportation of large masses of fat (see above, "Fat Grafts") In accordance with common usage Prudente's method is not a purely free form of transplantation Furthermore, he admits that after the muscle strip of the sternocleido muscle is isolated within a cervical tube it is transformed into fibrous tissue and that on implantation it recovers its normal histologic structure This has not been the experience of others nor, furthermore is it entirely consistent with bio physiologic facts In other words, muscle fibrosis is an irreversible phenomena

Indications for Its Use

The uses of muscle flaps in plastic surgery are comparatively limited Temporalis muscle flaps or slips may be used to disguise malar flattening, or they may be turned down and attached to the facial musculature to overcome paralysis of the orbicularis oculi muscle Slips of the masseter muscle have been employed by rotating them anteriorly in the cure of facial paralysis (see Fig 332) The transplantation of entire muscles per se (muscle substitution) may be included under this heading For such procedures the student is referred to texts on orthopedic or extremity surgery (see "Facial Paralysis")

Methods of Mobilization

When muscle tissue is used in the form of a pedicle graft it must be mobilized in line with the polarity of the muscle fibers Additionally one must be completely conversant with the innervation of the muscle so that the nerve supply is not injured, thereby destroying the integrity of the graft A paralyzed muscle flap is of no value All mobilizations of muscle flaps should be done with a view of avoiding, if at all possible, as much muscle bleeding as is consistent with the situation, for muscle bleeding is frequently one of the most difficult things to control All free ends of muscle flaps must be handled with the greatest care, and only instruments of positively atraumatic design should be used Next to the uselessness of a paralyzed muscle flap is the one which has been so traumatized that it turns into fibrous tissue

Methods of Fixation

The fixation of a muscle flap to its recipient site should be done with exceeding care and with meticulous apposition The least irritating of suture material should be used and that only sparingly The materials most often used are plain catgut or cotton It is important in the fixation of a muscle flap that it be put into position neither too tense nor too relaxed In the first case the sutures usually pull out of the muscle, and the object of the operation is defeated In the second case the muscle will shrink, atrophy or fibrose to a point where it is unable to perform its predesigned function

Postoperative Care

Wherever a muscle or muscle flap has been used with the view of re establishing function, the part must be splinted out of action until one is absolutely certain that a "take" has been established Muscle flaps "take" comparatively early Before any action of the part is permitted one must be on guard against hematoma formation, the price of which is fibrosis After a period of ten days it is fairly safe to assume that a "take" has occurred Between the tenth and the nineteenth days it is well to abstain from active motion Passive movements are advisable

TENDON GRAFTS

Types

Tendons may be transplanted either as free grafts or as pedicle grafts Almost any tendon reachable by the scalpel is amenable to use as a graft Only the finest of tendons, such as those found in the distal portions of the fingers or the toes, do not

Fig 143 The shaping of rib cartilage as support of the nasal dorsum (*Top, left*) Showing groove in underside of cartilage so it can be "saddled" over nasal septum and remains of bony frame work (*Top, center*) Showing shaping of dorsal aspect of cartilage graft Note outline mimicry of normal hump (*Top, right*) Inserting carved cartilage onto nasal dorsum via incision in vestibule A trial run to determine its adequacy as to length breadth, height and shape, as well as its ability to "saddle" nasal dorsum securely (*Bottom*) External trial run of combined dorsal and columellar grafts, after their junction by fitted swallow tail joint To insert this kind of graft, the purpose of which is total nasal support, an incision is needed running up one entire nasal side of the columella with extension unto the dorsum sufficient to permit pushing of long bar of cartilage to the glabella It is then anchored to nasal spine with wire or chromic gut

lend themselves, by virtue of their size, to easy transplantation The surgical trauma of repair apropos the size of the tendon is too great for the tendon to survive, particularly in a functional way It usually turns into fibrous tissue It is mechanically the height of difficulty to suture such fine tendons into recipient sites without causing too much trauma

Indications for Their Use

Tendon tissue never should be used for any other purpose except to supplant another tendon (or muscle) which has been lost, and only if the tendon's function is far more necessary as a graft to the welfare of the part than the need for the tendon in the normal location The outstanding indication for tendon grafts is loss of function in the hand due to destruction of its tendons At times tendons are also employed as grafts where portions of muscle have been lost, to bridge the gap between the remaining muscle tendon and the muscle proper They have been used as substitute material for entire muscles

In general the entire problem of tendon grafting may be summarized by saying that following a major injury to a tendon, it is as a rule, impossible to do an end to end suture Hence, a graft must be inserted Or

to put it another way, even after clean transection of a tendon, it is usually impossible to do a primary end to end suture after the lapse of from six weeks to two months This is due to retraction and fibrosis of the tendon stumps, so that after excision of the fibrosed ends the defect is too large to permit end to end anastomosis, and a graft is necessary

Tendon grafts of the smallest caliber consistent with their purpose should be selected One of the major reasons for the failure of tendon grafts aside from infection and surgical trauma, is the slowness with which the center of the graft receives nourishment in its transplanted position Very often the ends of the tendon will 'take' only for the graft as a whole to fail sooner or later because of central necrosis Where strength is an important factor, it is better to use two narrow or thin tendons parallel with each other than one graft so thick that its chances of final survival are small

Methods of Mobilization

Usually only the superficial tendons of the forearm, the hand, the leg and the foot are made available for free grafts An incision is made parallel with the course of the tendon preferably along Langer's lines of tension down to but never into the tendon This is best done with the help of suction or constant irrigation of the wound with saline (Koch) so that the tendon may be identified readily Before attacking the tendon proper, it is necessary that complete hemostasis be established Once the tendon has been identified and hemostasis is complete, it is gently lifted out of its bed with a pair of Mayo scissors, or a blunt hook If the entire circumference of the tendon is to be used, a clean incision across it should be made with the finest scalpel or preferably a portion of a razor blade The proximal and distal stumps of the remains of the tendon are tacked into position for future identification if more of the same tendon is to be used The portion removed as a graft should be handled with utmost gentleness so that its covering is not traumatized

The bed into which a tendon graft is to be placed must be absolutely dry, and there must be no fibrous tissue present Probably the most ideal bed for a tendon is one which consists of normal fatty tissue, but tendons may be implanted in the vicinity of any tissue including bone, just so the bone periosteum remains whole and the tendon covering is not injured

Methods of Fixation

The basic principles which govern adequate methods of fixation of tendon grafts are the following (1) The graft must be somewhat longer than seems necessary because of the unavoidable amount of postoperative shrinkage which is common to all grafts (2) The tendon must be under certain tension (3) It must be joined to the proximal and the distal fragments of the damaged tendon by sutures as few, as nonirritating and as dependable as possible Whatever the material used, it must be the finest It never should be placed in such a way as to strangle or twist either the graft or the tendon ends Finally, one never must place the sutures and the tendon ends in such fashion that the knots fall between the graft and the fractured ends of the tendon (Fig 143) For more detailed discussion of tendon repair see Chapter 28, 'Lower Extremities"

Fate of Tendon Grafts

A tendon graft receives its nourishment in the beginning only from the surrounding tissue juices and lymph until capillaries permeate its substance Hence, the wrapping of sutured tendon tissue in impermeable membranes or metal foil remains a questionable procedure In the meantime a certain amount of necrosis occurs within the center of the tendon Nonetheless, with the establishment of definite vascular com-

munion with its surroundings the interior of the tendon graft begins to be replaced by viable cells and tendon substance, unless it is too thick In due course of time (usually no longer than a period of about six weeks) the tendon graft begins to resemble a normal tendon in appearance, strength and integrity to a point where it is sometimes difficult to differentiate between it and the normal tissue

Obviously it is folly to transplant tendons of such diameter that vascularization of the center does not take place before complete necrosis If the central necrosis has gone to the point of liquefaction the entire tendon will slough and so never have the opportunity to regenerate

Ordinarily according to Mason for the first four to five days the communion between graft and recipient tendon is purely mechanical—only the sutures maintain the strength of the union From five to ten days later this union is augmented by a certain amount of cellular adhesion But the latter is attended and more than paralleled by a degree of central necrosis It is for this reason that the most vulnerable period in tendon grafting is the tenth to the fourteenth or even the nineteenth day During this period active movements must be guarded passive motion on the other hand should be encouraged

NERVE GRAFTS

In the field of tissue transplantation probably no greater differences of opinion discrepancies in reports of clinical as well as research material and interpretation of results exist than in the field of nerve grafting The most that can be said at the present time, in spite of the vast experience with nerve surgery in World War II, is that primary, early, end to end, accurate, meticulous anastomosis of nerve ends is by far the best method in the repair of injured nerves Secondly, a fresh autograft in certain instances has a fair chance of success and for all practical purposes the homograft thus far has proven to be inadmissible and a complete failure

Types of Grafts

As with other forms of grafts the nerve graft can be divided into the free type and what might be likened to or called the pedicle type of graft The former is the usual type of graft consisting of a part of a spare cutaneous nerve The latter type is exemplified by the transfer for instance of the hypoglossal nerve in facial paralysis

Sources of Nerve Grafts

The many and easily available nerves in the body would at first seem to make the source of supply for grafts an ample one But when one considers the indispensability of nerves to good function the sources are reduced to few Other important factors determine the feasibility of a donor site such as ease of surgical approach length of nerve available its diameter possibility of trophic ulceration anesthesia postoperative dysfunction, pain etc

Hence the most commonly employed nerves as graft material are the sural saphenous superior peroneal posterior femoral cutaneous lateral femoral cutaneous, medial and lateral antibrachial cutaneous Others may be approached in case of unavoidable necessity but the functional price is much higher than with the aforementioned nerves

Indications for Grafting

The only reasonable indication for nerve grafting is where there is actual loss of nerve substance to a degree precluding end to end anastomosis Even so, based upon what experience we have it is wise to wait at least from six months to a year before making the decision to free graft a nerve defect This rests on the basis that, first of all, the conditions necessary for the success of a nerve graft demand such ideal environment that it is rarely found in traumatic cases, and secondly, because under the con

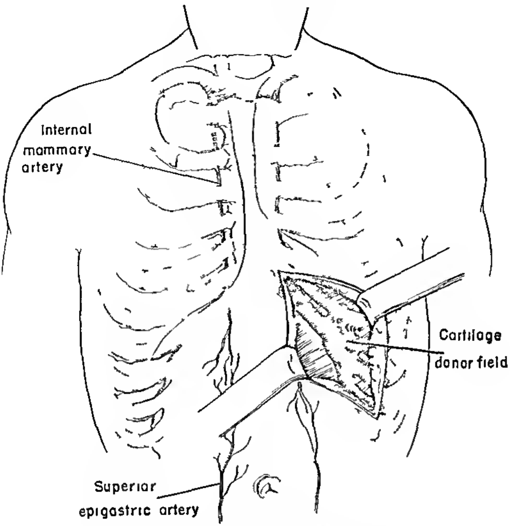


FIG 144 Mobilization of costal cartilage as a free graft

ditions which usually prevail the percentage of successes of nerve grafting are still too small to make the venture possible with abandon Where there is a record of actual loss of part of an important nerve trunk or where the postoperative story is to the effect that the patient is constantly suffering from irritation to the nerve ends or definite evidence of atrophy and functional regression one is justified in considering nerve grafting

METHODS OF MOBILIZATION

The manner of acquisition of a nerve graft is comparatively simple Emphasis is laid upon the necessity for mobilizing the graft with the sharpest possible instrument available such as a very fine razor blade At the time of mobilization one should identify immediately the polarity as well as the circumferential position of the nerve so that when the graft is transferred the substance of it is not twisted or rotated clockwise or anticlockwise In other words the fiber ends of the graft must be vis a vis the fiber ends of the recipient nerve stumps (Fig 95)

METHODS OF FIXATION

In the implantation of a free nerve graft certain basic fundamentals must be observed First of all the ends of the severed

nerve must be removed to a point where one is absolutely certain that the remaining stump is viable This applies particularly to the proximal fragment of the nerve Secondly, one must be absolutely sure that the bed into which the nerve graft is placed is devoid of all fibrous tissue and foreign material and is as vascular as possible Thirdly, the placement of the nerve graft, as indicated heretofore, must be as nearly consistent with clockwise position and polarity of the nerve ends as possible

The actual suturing of the graft to the nerve ends must be done with the finest available material, whether it be silk, cotton or whatever the choice Sutures must pass only through the nerve sheath (Fig 144) The practice of enveloping the sutured nerve ends in substances such as tantalum foil has not proved to be a good practice Since the nerve graft is entirely dependent for the first few days upon the nourishment which it can get from its bed, the shutting out of the tissue juices by any impermeable substance whatsoever is contrary to physiologic knowledge Where such material has been used, it must frequently be removed before good results are obtained

The sectioning of nerves to be used as grafts—done two or three weeks prior to their transfer because of the Wallerian degeneration which the graft must undergo, thus taking advantage of the degeneration before transfer of the graft—has not thus far proved to be of material assistance in the end results obtained

In the face of general agreement that nerve grafting be not done prior to the lapse of from six months to a year, attention must be called to the necessity for maintaining the integrity of the paralyzed muscles by means of physiotherapy and various supports This is a vital precaution Otherwise, after regeneration of the nerve and its re-innervation of the musculature, the latter will be unable to function due to atrophy of disuse and fibrosis of the paralyzed muscle mass This is particularly evident in old neglected facial paralysis I have not infrequently seen cases where even after the lapse of two years there were evidences of the regeneration of the facial nerve but never an adequate return of muscle function Because in the intervening period the musculature was allowed to be overstretched, atrophied or even fibrosed

Nerve Homografts

As late as 1920 the Medical Research Council reported that ' Nerve Grafts should only be adopted as a substitute for end to end suture in those very rare instances where it is absolutely impossible to bring about direct approximation "

Later accounts, by Sanders in 1942 and by Spurling, Lyons, Whitcomb and Woodhall in 1945, stress the unqualified failure of the nerve homograft in man This is interesting in contrast with experimental reports by Sanders and Young in 1942, by Bacsich and Wyburn in 1945 and by Bentley and Hill in 1940 Sanders and Young reported successful nerve homografts in cats, and Bentley and Hill a success following the repair of the external popliteal nerve in monkeys by homografts up to three inches in length They were able to elicit satisfactory motor response to electrical stimulation of the nerve and in some cases even observed numbers of nerve fibers throughout the length of the homograft

Barnes, Bacsich, Wyburn and Kerr (in 1946) came to the following conclusion

> The present report on the results of eight cases of human nerve homografts once more confirms with what can now be regarded as the normal expectation of the complete failure of this method of repair of gaps in the large nerves of the limbs
>
> Therefore, although from the standpoint of the surgeon the nerve homograft should be regarded as an incontrovertible failure, the experimentalist is tempted to further investigation by the tantalizing, histological picture of partial success *

* Barnes, R, Bacsich P, Wyburn, G M, and Kerr, A S A study of the fate of nerve homografts in man Brit J Surg 34 34-41, 1946

The preceding coincides with the report of Bentley and Hill in 1936 They believe that the function of the graft is simply to provide a necessary temporary scaffolding for the ingrowing new fibers Success depends upon the nerve fibers reaching the peripheral stump while the graft is still in a condition to act as a scaffold This condition by way of explanation of facts available is entirely dependent upon the time that it takes for the host to develop an immunity to the homograft and to destroy it by infiltration of fibrous tissue to the point of total obliteration In this connection Barnes et al add that,

> The older the graft the more difficult it becomes to distinguish it from surrounding tissues until finally the only clue to its identity is the knowledge of its former position (as in their case number 3) where even on microscopic examination there is no evidence of the original graft *

Hence it is logical to assume that unless a method is found for prolonging the presence of the homograft or deferring the immunity action on the part of the host, there is no justification for the use of the homograft

In line with this it must be noted that the fate of a nerve homograft is basically different from the fate of an autograft or even an isolated peripheral stump In the autograft the architectural characteristics of the tissue are preserved, while fibrosis is the result of the proliferation of its own connective tissue elements This in many ways represents conditions prevalent in an isolated peripheral stump although in the latter eventual though imperfect innervation is possible according to Barnes

CARTILAGE GRAFTS

Autogenous cartilage is undoubtedly one of the most frequently used tissues as a graft Homogenous cartilage is still rather extensively used by some surgeons, although on the basis of experiences in World War II it would seem that the merits assigned to it have not been borne out to the extent that the literature of the decade preceding the war would seem to indicate Surgeons who have had ample opportunity to use cartilage extensively in the repair of major defects, consequent upon war injury, generally agree that the results obtained with homogenous cartilage are so inferior to those obtained with autogenous tissue that the former is not to be recommended except in unusual circumstances This becomes more evident where one is able to follow cases for two or three years Homogenous cartilage rarely survives where it has to carry any load If exposed to stresses or repeated sudden temperature changes, as in exposed parts of the body, it soon liquefies and is extruded or absorbed If, on the other band, it is placed in a bed of minimal stresses, it may survive for long periods of time or, in occasional cases, permanently Such beds are rare The usual result is a fibrosed mass, subserving essentially formative needs

Types of Grafts

Cartilage grafts, like most other grafts, are of two types the free and the pedicle graft The latter, though restricted to certain specific situations, nevertheless exists, as in the restoration of minimal deviations of the nose, the ear and the eyelid In these situations the fine thin cartilages making up the framework of these parts may be divided into parts or sections still attached by a peduncle to their source of origin and transposed or rotated for the purpose of filling in minor defects of contour This is particularly true in the case of the nose In general, the cartilage graft is for the most part used as a free graft (Fig 144) As such it may be used immediately after its mobilization, as a deferred graft, a delayed graft a stored graft or transferred to another recipient as a homograft (see p 296)

Usually cartilage grafts are transferred in one piece This has certain disadvantages

* Barnes R Bacsich P Wyburn G M and Kerr A S A study of the fate of nerve homografts in man Brit J Surg 34 1946

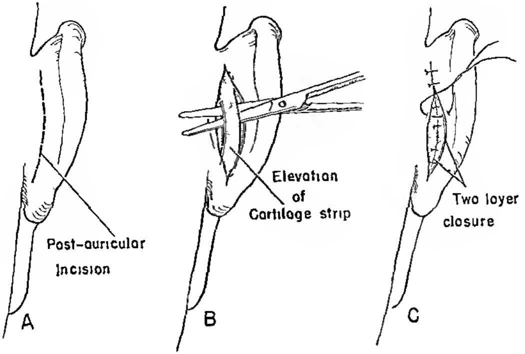


FIG 145 Mobilization of auricular cartilage as a free graft

The cardinal one is central necrosis or warping after transplantation Even though cartilage is known to live mostly by diffusion of lymph through its channels in a large graft the lymph does not reach the center When the center of the cartilage necroses, so called toxins of necrosis are liberated which act as local irritants leading to early extrusion Secondly such autogenous cartilage is difficult to shape in the many details and contours of the ear for instance

Indications for Its Use

Cartilage grafts are indicated where bone or cartilage loss has been sustained and *form or function are affected*

Methods of Mobilization

Only a limited amount of cartilage is available in the human body For ordinary reconstructions this is usually sufficient. Although some authors are inclined to take the position that enough cartilage is seldom available, it is my opinion that if cartilage is used wisely where only cartilage is required ample tissue is usually available The discrepancy arises in the fact that frequently cartilage is imposed into bodily defects where it has no logical or physiologic place to begin with Finally many of the restorations which are commonly done by cartilage might better be done either by a dermic or a fascial graft or in more extensive cases, by bone

The major sources of cartilage in the *human body are the rib the ear the nose* and occasionally the cartilaginous surfaces of the major joints available following major amputations

In mobilizing rib cartilage a more or less vertical incision is made over the region of the eighth the ninth and the tenth costal cartilages and the last is carefully exposed without injuring the perichondrium (Fig 145) The costal cartilage is carefully freed from its bed so that a stripper can be insinuated under it It is then completely freed from its surrounding tissues, and a section is removed In the event that the

Fig 146 (*Left*) Extensive gable shaped iliac bone graft inserted, 3 months previously, into a nose which originally was completely splayed This was the result of an automobile accident 15 years before The bone graft was inserted subperiosteally through the intranasal approach into a small subperiosteal niche made with an osteotome, as shown in dark outline of frontal bone Note amount of absorption of the graft where it leaves the maxilla (clinically the lateral side of the nose), also note absorption in distal extremity of the graft which was originally repaired (*Right*) Two and one half years postoperatively This shows the bone graft to be viable and securely attached to the niche in the frontal bone Particular attention is directed to the fact that the bone graft has survived to a satisfactory degree roentgenographically, although it was originally attached at one end only Whereas the patient had complete bilateral obstruction to breathing prior to operation he acquired adequate airways on both sides The psychological and personality changes were immediate positive and lasting

entire thickness of the cartilage is not needed it is sufficient to plane off whatever thickness and length of cartilage is necessary This may be mobilized with or without the perichondrium, depending upon its destination and purpose Where it is intended only to fill out a soft tissue depression, a perichondrial cartilage is adequate Where it is to replace bone or abut against it, it is necessary to remove it with its perichondrial layer Where it is required to maintain form, it should have perichondrium only on its concave side

Since rather frequently following its removal from a rib the patient for a time complains of pain in the region of the donor site, it is the practice to block the intercostal nerves with 70 per cent alcohol After complete healing and organization of the bed the pain usually subsides

The ears are a good and easy source for small amounts of cartilage, particularly efficient for restorations of a saddle nose A thin strip of cartilage is almost routinely available in the ear up to one and one half by three eighths of an inch If a strip is removed from both ears, this is usually adequate to restore most types of nasal deformity due to exclusive loss of cartilaginous material The cartilage is easily mobilized through an incision on the posterior aspect of the ear, running vertically and down to the perichondrium The only precaution necessary is that the thin anterior skin, which is frequently quite adherent to the perichondrium, be not perforated during the mobilization and that in closing the donor ear, it is not deformed by careless suturing (Fig 146) (See also "Composite Grafts")

The nose itself is a source for a minimal amount of cartilage This is usually made available in the course of a rhinoplasty and used for the correction of very small defects of the same nose It is available by doing a conventional submucous exposure of the septum and removing sections thereof, either by shaving or deliberate removal of

full thickness of cartilage from the center thereof in the same manner as is done in a submucous resection

Methods of Implantation and Fixation

Cartilage may be simply carved and laid into an accurately prepared bed, sutured or wedged into a recipient site or shredded, diced and molded into a desired shape by previously designed external molds When pieces of cartilage are used as grafts and convexity or concavity of surface is to be maintained it is well to bear in mind that cartilage will always bend in the direction of its perichondrium covered surface

Blair many years ago devised the expedient of threading a piece of cartilage on to a long needle and then partially sectioning the rod of tissue into blocks of about ½ cm in length This to a large degree avoids warping It also exposes considerable of the interior of the cartilage and at one and the same time aids in the better allocation of the graft to the nasal dorsum

Gordon New more recently devised the idea of boiling the cartilage prior to its use as a graft This of course immediately destroys its viability In the course of the boiling the cartilage invariably warps This warping, ostensibly permanent and exclusive, allows one to realize immediately what otherwise may happen after implantation One can thus carve the necessary portion before implantation in the shape and the form in which it is intended to remain permanently

Because of the difficulties in the shaping of large grafts of cartilage and secondly because of the relatively moderate amount of cartilage available for large facial restorations, Forrest Young has conceived two novel approaches to the problem They are the Cast Cartilage Grafts and 'Precast Cartilage Grafts '

His description of the method is as follows

Cast Cartilage Grafts—The best material for use in the restoration of lost parts of the facial skeleton is autogenous costal cartilage It has long been used as solid grafts carved to the desired shape This method has disadvantages Among these are the lack of large enough pieces of cartilage to restore large losses the inability to model the grafts to exact shape in the short time available at operation the difficulty of fixation and the tendency of solid cartilage grafts to subsequently warp

Previously reported animal experiments show that small bits of cartilage buried together in the subcutaneous tissues adhere by fibrous tissue In this way grafts of cartilage having the physical properties of elastic fibrocartilage can be produced

This method has been used in restoring lost facial contour The fine details of facial form can be restored by implanting a mass of cartilage particles subcutaneously and maintaining them in exact shape as they heal together by appropriately constructed latex forms The implanted cartilage is thus cast in situ in an exact predetermined replica of the part desired

Precast Cartilage Grafts—In certain locations thin elastic cartilage grafts of complicated contour are desirable In reproducing the cartilage for example of an ear even greater difficulties are encountered if an attempt is made to use a solid carved graft Cartilage of sufficient size is not available and the carving of the complicated contour is time consuming and difficult An exact replica of an ear cartilage can be reproduced by filling a fenestrated metal form with finely divided cartilage and burying this in the subcutaneous tissues In three months time the particles are adherent and can be removed from the form as a thin, elastic sheet of cartilage which has the exact contour of the detailed configuration of an ear This replica of ear cartilage can be used as the skeletal support for reconstruction of the ear will retain its form and shape and when covered with mastoid skin closely simulates a normal ear *

The principle involved can be applied with considerable saving of time, if shavings of cartilage are taken which have the natural tendency to curl an advantage in ear reconstruction These are then inserted, in the sizes and the direction of curvature needed, under the mastoid skin When this

* Young Forrest Cast and precast cartilage grafts Surg 15 748 1944

is re elevated a cervical extension of the flap is mobilized, sufficient to cover the back of new ear Before folding the cervical portion of the flap over the mastoid portion, the cartilage is crosshatched A metal mold is then applied externally over the new ears and is worn for six weeks This shapes the extensively crosshatched cartilage within the already established ear flaps

The student must remember that all these methods are as yet but attempts at the construction of an ear which in certain cases managed by the operator conversant with the method may give fairly satisfactory results Ultimately, it must be emphasized that the problem of ear reconstruction is still in a state of flux and in general very unsatisfactory

The Cartilage Homograft

As indicated, heretofore, the search for adequate sources of cartilage has resulted in the past decade in recourse to homocartilage The question of its permanent adequacy as a graft is a matter of consistent dispute Most authors, like Straith, Pierce, O Connor, Firestone and others, on the basis of their experience hold that homocartilage is equal to autocartilage as a graft In fact a few authors are inclined to leave the impression that homocartilage even exceeds the usefulness of autocartilage

The ultimate problem with some seems not to be a question of autogenous pre eminence, but rather which type of homocartilage is the best That is, whether the viable form, which is transferred immediately upon its mobilization, the preserved, or the inert (boiled or frozen) is the best The fact remains that all such cartilage, preserved or boiled, is nonviable, biologic foreign matter The contention of Firestone is that the failures with the use of preserved cartilage are in great part due to the preservative itself, whereas the objection of other authors is that boiled cartilage is far more irritating per se than preserved cartilage

Experimental work concerning homogenous transplants of living or dead cartilage is not sufficient to draw any fixed conclusions Loeb reports that there is much more tissue reaction to and absorption of homocartilage as compared with autocartilage Peer reports on cadaver cartilage which has been preserved in alcohol, implanted into the skin of patients and removed at intervals of about a week up to two years Histologic examination of the removed sections showed that an intense inflammatory reaction took place almost immediately Following this a thick connective tissue walling off took place which lasted about a month Thereafter the cartilage remained more or less as an inert, biologic foreign body up to about nine months From then on there was consistent invasion of the cartilage by fibrous tissue of the host and eventual absorption

The latest proponents of other than autogenous grafts are W E M Wardill, M B, and John Swinney, M D, of England who contend that prepared animal cartilage may be used in reconstructive surgery Operating time is shorter than with autogenous grafts Several trials for the best possible final result may be made, since animal cartilage is easier to obtain than either autogenous grafts or cadaver material Transplanted bovine cartilage resists infection, does not provoke tissue reaction and may be prepared commercially like catgut, they contend

The most suitable bovine cartilage for plastic purposes, they advise, is from the xiphisternum The material is removed under surgically clean conditions and placed in sterile, dry bottles Later, under aseptic conditions, the soft tissues and perichondrium are dissected off Cartilage is immersed in boiling water for one minute and then preserved in sterile bottles containing 1 4 000 merthiolate in normal saline Preserving solution is renewed the next day and once a week thereafter

Personally, I have in certain selected

instances had good results with all forms of cartilage Nevertheless, the over all percentage of good long term results by the use of any other form of cartilage does not compare with the large percentage of excellent results obtained with autocartilage, nor is the percentage of good results obtained by homocartilage sufficiently large to outweigh the percentage of inadequate results This is the consensus of opinion of plastic surgeons who have had opportunity to employ all forms of cartilage in World War II in a large number of cases

BONE GRAFTS

Historical

The use of bone in the form of a graft is a comparatively recent clinical venture, in spite of the fact that the idea of bone transplantation is mentioned in the literature of antiquity and that certain experimental attempts have been made a century or more ago The cynicism surrounding the transplantation of bone and the attitude of negation in that respect are best expressed in a statement by Cole, in his report on bone grafting during the first World War (1919) as follows "Occasionally active hostility was encountered "*

Prior to World War I most of the literature dealt with the *origin of bone growth* and bone repair The tendency in that direction is rapidly returning after World War II The impetus to such effort is the ever present necessity for understanding and explaining the results of the enormous amount of bone grafting done in the late war

The original practice of bone transplantation may probably be credited first to the French surgeons, pre eminently Ollier He called attention as early as 1859 to his work on the exchange of segments of the radius from one foreleg to the other in rabbits and emphasized the fact that success is obtained by autogenous grafts rather than any other It was not until 1875 that the Germans, through Nussbaum, began to advocate the rotating of a fragment of bone still attached at one end in an attempt to bridge defects of the ulna by faceting it across a two inch defect at one end This seems to be the first record of what might be compared with the modern slide graft in bridging defects in long bones It was not until 1881 that Macewen reported his observations on the transplantation of small chips of bone It was his thesis that bone could be transplanted and grow to produce satisfactory results in the repair of bone defects Possibly upon Macewen s earlier report, Sir William Heath's Dictionary of Practical Surgery (Philadelphia, 1886) expressed the opinion that bone should be transplanted in very small fragments about the size of a pea, if consistently good results were to be attained He suggested that the use of large bone grafts was inconsistent with survival, because of their likelihood to undergo necrosis This, of course, is parallel with clinical experience as it applies to other grafts

Not until the turn of the century was bone grafting taken up seriously, from the clinical standpoint Eric Lexer was one of its first exponents In 1907 he published considerable material on the question of bone transplantation, particularly in connection with the transfer of entire joints Following his publications, interest in the clinical transfer of bone grafts spread to America One of its earliest advocates in this country was Albee, who seems to have been primarily interested in the transfer of massive bone grafts in contrast with Campbell who can be said to have been the father of the onlay graft With Albee and Campbell, the primary concern was not which cell is responsible for bone repair or whether a bone graft, of whatever dimensions, actually survives or merely acts as a bridge for new bone formation They gave precedence to the clinical problem of the benefits to be

* Cole, P., and Bubb C H Bone grafting in ununited fractures of the mandible, Brit M J 1 67, 1919

derived from the transfer of bone per se Orr puts the matter thus

It appears that much time has been wasted in trying to decide how many or what cells in the parent tissue or in the graft were responsible for ultimate union in fractures It is entirely conceivable as some have maintained that the graft itself furnishes no osteogenic factors and that all bone growth proceeds from the receiving portions of the bone However the apparent viability of some grafts and their participation in the repair process appears to be so convincing that it seems quite likely that at different times and under different circumstances grafts and the parent bone participate in different degrees in contributing to the success of this surgical procedure *

No great impetus to bone grafting took place until World War I During that period and immediately following it comparatively large series of bone grafting operations were reported particularly by the French and the Germans At that time Vilray P Blair summarized the situation in the following words No part of facial reconstruction received greater impetus during the war than bone grafting of the lower jaw † This was not so much due to a primary interest in bone grafts per se as to the need for doing something about the horrible facial disfigurements of that war Nonetheless the benefits which accrued from this experience not only to reconstructive surgery but also to understanding more of the clinical behavior and the end results of bone grafting have been immeasurable

From the time of World War I until World War II the clinical interest and the application of bone grafts to human cases seems on the surface at least to have overshadowed completely the academic and scientific interest in the nature of bone growth and repair both in the donor and the recipient tissues but after the establishment of certain clinical success old and basic questions in new guise presented themselves The first was whether or not the bone graft actually survives or is replaced by new ingrowing bone The second was whether or not there was any difference ultimately in the transplantation of cancellous as compared with cortical bone One school of thought maintained that only the transplantation of cortical bone was consistent the other that the transplantation of cancellous bone was equal to the former if not better It is still to a degree the problem of our day It is partially due to the fact that until recently cortical bone has been used almost exclusively as a graft

Nature of Bone Repair

Impetus to the cancellous and the cortical schools was given by Mowlem who in 1941 reported that he secured much more rapid union when cancellous bone chips were used than when cortical grafts were employed He showed that upon removing histologic specimens of iliac bone grafts five months after their insertion for repair of the bridge of the nose these sections showed that transplanted cancellous bone transformed itself into cortical bone but what seemed to be of greatest moment was his contention that the cells of the cancellous graft remained alive Further than that these cancellous chips seemed to resist infection where cortical bone would not Finally while cortical bone grafts remained cortical in structure the lacunar cells appeared to be dead and the bone graft had not yet been replaced by living bone five or six months after the operation This gave rise to the theory of creeping substitution which means that a cortical graft after dying is gradually replaced by bone from adjacent bone structure and the function of the graft is simply that of a splint for the increeping of new bone and a source of calcium In contrast cancellous bone which because of its sponginess is permeated very rapidly by blood vessels and tissue fluid

* Orr H W The history of bone transplantation in general and orthopedic surgery Am J Surg (New Series) 43 547 553 1939

† Blair V P Some observations on our war experiences with face and jaw injuries Mil Surg 47 3 9 1920

survives completely after transplantation Basically this is the concept of Axhausen

Creeping substitution can hardly explain the survival of massive bone grafts in toto when the latter are attached to bone by only one end This point becomes clearer and is substantiated by the recent tendency in plastic surgery to reconstruct nasal bony losses by approximation of single bone grafts by one extremity to the frontal region Even so most of these bone grafts to the nasal dorsum solely attached to glabellar bone only remain in contact with the latter by fibrous union (Fig 147)

Another and more formidable illustration is the bony bar or peg used in the tubular reconstruction of a missing thumb The free end of the bone graft survives almost as well as the proximal one attached to a metacarpal

Further confusion of the subject resulted when Stewart Gordon in August of the same year said

Considerable experimental work has been done to test Mowlem s contention that cancellous grafts live The work was carried out on dogs Sections obtained at intervals have been studied by Dr A Ham Professor of Histology in the University of Toronto It would appear that cancellous chip grafts die and are gradually absorbed and replaced Some small areas of new bone formation from the endosteum and possibly marrow cells are observed

Cancellous Chip Grafts have a very definite and valuable place in plastic surgery in my opinion Contrary to most stated opinions I believe from experimental evidence that the bone cells of such transplants die Speed of union is the result of the marked stimulus of bone formation from periosteum bone and endosteum of the recipient site and the ease with which cancellous chips may be overlayed and replaced I am at a loss to account for the reaction of cancellous chip grafts to infection *

In the same year Horowitz and Lambert give the following opinion

There has been considerable controversy over the relative merits of cortical vs iliac bone as graft material, the essence of which

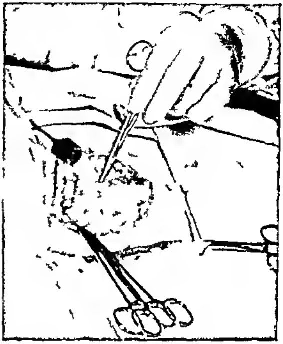


Fig 147 Exposure of right iliac crest as donor site for bone graft An incision 3 inches long is made to the crest through the skin and subcutaneous tissue Point of hemostat rests on the iliac crest still covered by fascia and muscle (cf Fig 148)

seems to be that while bone from the ilium is more readily revascularized and incorporated into the host bone because of its cancellous nature tibial bone has the advantage of being rigid enough to give good internal fixation to the host bone when fixed to it with screws The authors feel however that what iliac bone lacks in rigidity is more than compensated for by its superior osteogenic qualities and that the simple addition of a plate imparts the required stability †

Brown commenting on the nature of the end results obtained by using cortical bone as graft following the extirpation of bone tumors concludes that

These grafts have evidently not received any assistance from the periosteum in their

* Gordon Stuart The role of cancellous bone in plastic surgery Surg 20 202 203 1946

† Horwitz T and Lambert R G Massive iliac bone grafts in the treatment of ununited fractures and large defects of long bones the combined bone graft metallic plate technique An analysis of 91 operations in 85 patients Surg., Gynec. & Obst 84 435 1947

survival, since in each periosteum of the recipient bone was completely removed with the tumor and the bone grafts were inserted without any periosteum attached to it Neither can it be said that these grafts have been replaced by creeping substitution from the bones with which they were in contact If this had been the case one would have expected radiological evidence in the form of a decalcified line of demarcation gradually spreading from the ends towards the center of the graft *

He admits, however, that it is finally impossible to refute the argument that the grafts may have died and were replaced by cells from the organizing hematoma It is as difficult to deny that these replacement cells subsequently become differentiated into bone elements The latter of course is parallel with the teaching of Leriche and Policard, whose thesis is that bone may form wherever there is primitive mesenchyma and sufficient calcium and blood supply Hudack et al of Columbia University in principle present further evidence to support the thesis of Leriche To the question as to why bone will form in unnatural places like the corpora cavernosa (A G Gerster) or muscle Hudack states

> Heterotropic bone formation again simply supports the concept that so called specific osteoblasts are not necessary in the formation of this type of bone There are no osteoblasts in epigastric scars Inferentially, one is drawn to the hypothesis that the undifferentiated fibroblast which is present as a response to injury is capable of differentiating so that whatever materials are necessary biologically or physically for the production of bone at that particular site if there is some factor which the living cell contributes—and I am confident that eventually we will learn that that is so—it does not have to be the so called specialist osteoblast but these cells may derive from the primitive cells which are present in response to injury in any region †

To this interesting state of affairs must be added the work of Bogolomets who in 1944 reported on an experiment involving 800 rabbits He claims that small doses of antireticular cytotoxic serum accelerated the healing time of fractures about 1 5 times as compared with the healing of fractures in nonstimulated animals Further, he maintained that control experiments showed that the stimulating action of the antireticular cytotoxic serum is not one of a nonspecific protein reaction His work seems to have been adequately verified by Straus, Horwitz, Levinthal, Cohen and Runjavec who conclude that stimulation of the healing of experimentally produced fractures in rabbits can be induced with small doses of antireticular cytotoxic serum and depression of healing by massive doses, parallel with the findings of Russian investigators

Arvid Hellstadius, of Stockholm, recently reported on well controlled experiments where repeated subperiosteal injections of blood plasma, marrow extract, marrow autolysate and extract of muscular tissue ' with and without 'fracture edema' provoke, as a rule, abundant formation of new periosteal tissue on the surface of the bone " He goes on to say that, in other control experiments with normal saline exclusively, new periosteal tissue formed which was adequate He feels that the new osteoid tissue, formed as a result of the repeated subperiosteal injections of the above substances, is either entirely or in a high degree due to purely mechanical influences He concludes by saying

> In the new periosteal tissue thus attained, in no instance a roentgenoparent calcareous deposit was to be found Such a deposit was, however, observed when the injections were made on cortical bone previously having been damaged with a sharp raspatory *Thus a lesion of the cortex is essential for the origination of true, new bone formation* This calcareous periosteal new bone deposit could be as thick in cases only treated with normal saline as in those where marrow extract or plasma has been injected On the other hand, calcification did not result from injections of suspensions of ground bone or Robinson's calcium phosphorus solution into the osteoid tissue Injec

* Brown David Survival of cortical bone after bone grafting Brit M J 1 389 1946

† Hudack S S Blunt, J W., and Darby E K A study of bone matrix, Am J Surg 74 579 1947

tions around fracture ends gave a negative result Nor was an intensification of callous formation achieved by covering the fracture ends with plasma coagulated by boiling *

The latter experimental work is noted because it seems probable from experience that the healing which attends transplantation of bone in the form of a graft occurs in much the same fashion as follows primary fracture In other words, blood is poured into the defect which then clots in the bed, and an invasion of organized vascular connective tissue follows at a rate which is in inverse proportion to the density of the graft Following thus a certain amount of bony absorption occurs and finally a re deposit of calcium, leading to firm union

The incontrovertible fact nevertheless remains that although this similarity exists between the healing of a primary fracture and that which attends bone grafting, in fractures with the loss of considerable bone substance tissue continuity is not re established without the interposition of a bone graft or, according to Hudack, 'of some inert artificial matrix (monofilament nylon) " The second noteworthy point is that whereas the primary fracture heals by callous formation, which means by fibrosis, in the case of interposition of a graft the defect eventually shows normal bone continuity In other words, in cases where extensive bone loss has occurred, bone grafting like suturing is the sine qua non for re establishing histologic or morphologic tissue continuity which otherwise may never occur

In a manner of speaking this may be likened to the principles underlying skin grafting Where the loss of skin does not involve the entire thickness and the defect is not too large, the epithelium from the surrounding good skin and the hair follicles remaining in the subcutaneous tissue may completely cover the defect without any apparent disturbance of the function or appearance of the part Where the defect is so extensive that nature cannot repair it by the ingrowth of epithelium, and because derma as such does not seem to regenerate to any marked degree, skin grafting must be resorted to, to bridge the gap Otherwise morphologic healing does not occur and is substituted by fibrous tissue

* Hellstadius Arvid A study of new bone formation provoked by subperiosteal injections of blood plasma extract of bone marrow, etc Acta Chir Scandinavia 95 Fasc I II, 1947

Biophysiology of Bone Growth and Grafting

To leave the matter at this point would be to deprive the student of the important meaning and synthesis of the facts brought out by clinical and experimental evidence It is obvious that contemporary clinicians are divided into two major schools as to the ideal form of bone graft cortical or cancellous The solution to the problem will remain difficult so long as we conceive of it from a purely physical or anatomic perspective

As with skin grafting it is necessary to take a physiologic perspective of the tissue in order to arrive at fundamentals Skin grafting can be understood only when it is realized that a certain fraction of skin the epithelial, has the power of growth and regeneration The derma probably regenerates little if at all Hence, true functional rehabilitation through skin grafting can be accomplished only when as much of its epithelial elements are transferred with the graft as is possible The ideal form of transfer, therefore, is the full thickness skin graft, but the full thickness graft needs an ideal bed, otherwise its glandular constituents, such as the sebaceous glands and ducts, will atrophy and fail to produce new epithelium Contrariwise, where complete destruction of skin has not occurred, complete regeneration may follow from the remains of epithelial islands If the size of the wound is within certain limits, regeneration may be so nearly complete as to disguise all signs of injury after healing Such regeneration assumes and demands minimal ex

traneous meddling, viz, surgical trauma, chemical applications, dressings, etc

The entire proposition of normal tissue survival or reconstitution, whether it be skin or bone, may be reduced to the fundamental triad of (1) the presence of the necessary histologic building stones, (2) a physiologic environment for the normal growth or conservation of the elements, and (3) protection of the growing or organizing tissue against any form of intrusion inimical to survival until final functional organization is complete

Hence the argument as to which is preferable cancellous or cortical bone as a graft is only a physical rather than a physiologic perspective of a biologic issue and at best can result in only empiric conclusions Unless all three criteria of the aforementioned triad are given equal consideration and are basically understood, the pendulum in bone grafting will continue to swing between two physical extremes, as it has until recently in skin grafting

The facts as concerns the first criterion are that bone is an ever dying, always growing morphologic unit Fracture or no, bone loss or not normally bone is constantly being broken down and as persistently reformed The reformation is entirely dependent upon the presence of certain living cells with the ability or the potentiality of reforming bone whether they be found in a graft the injured bone ends or primitive mesenchyme In the first and the second instances the able cell is the so called osteocyte which under certain periodic cycles of stimulation becomes the osteoblastic building stone The chemical details of its mode of action whether by secretion of bone components or precipitation due to CO_2 tension is irrelevant to the physiologic problems of bone grafting The biologic fact remains that where the osteoblastic factor' is absent or unable to function bone will not develop An equal amount of mystery surrounds the mechanism of action and significance of the potentially able' cell derived from the primitive mesenchyme

True, osteoblasts can be found practically in all histologic layers of the bone, but in different quantity and variable accessibility to circulation The latter involves the importance of the second factor in bone grafting, namely, physiologic environment Whatever part of bone (periosteum, cortex or its cancellous portion) is transplanted, theoretically it should survive or regenerate, but obviously, since periosteum and the endosteum of the cancellous portion contain the greatest volume of cells of osteoblastic potency, grafts made up for the most part of cancellous bone with periosteum should constitute the most ideal graft from a biologic standpoint Nonetheless, these building stones will only generate their kind if the environment (recipient site) is fully capable of providing the elements and the physicochemical protection for their proper morphologic growth It is essentially a question of circulation, sustenance and *exclusion of tissues inimical to bone growth from the void consequent upon fracture or loss* The last is probably the explanation for the function of Hudack s inert matrix' (filamentous nylon) in aiding bone regeneration The same factors undoubtedly stand paramount in Kazanjian s case of Spontaneous Regeneration of Bone following Excision of Section of the Mandible'* The periosteal trough which he took pains to preserve prevented insinuation of cheek tissues into the postoperative void, and complete regeneration followed

From a clinical standpoint then, the best type of bone graft would be one consisting mainly of cancellous bone, enough cortex to guarantee some rigidity and intact periosteum to insure early vascularization of the cortex, thus conserving whatever osteoblastic elements may be present Barring the possibility of the latter the clinical end result must depend on 'creeping substitution,' a process needing months for its com

*Am J Orthodontics *32* 242, 1946

pletion, hence, the import of the circulatory integrity of the recipient site and avoidance of unnecessary trauma to the graft Even so substitution' will not take place where *bone ends are separated by morphologically* strange tissue or dead space

Apropos the foregoing it would be diffi cult to pick any random contemporary series of cases in substantiation or refutation of certain basic considerations so long as bone grafting is done more in the spirit of car pentry than physiologic transfer of tissue The same basic difficulties plagued skin grafting until the imperativeness of under standing skin in physiologic terms, the necessity of *certain recipient sites for cer* tain types of grafts and the importance of splinting, avoidance of undue surgical trauma and interposition of foreign matter was appreciated and consistently exercised

Notwithstanding, this appreciation of vital principles is gaining, as exemplified in the work of L C Abbott Schottstaedt, Saunders and Bost, of the University of California, who after three years of con trolled experiments come to the conclusion that

> Our studies have permitted us to arrive at very definite conclusions with respect to the evaluation of cancellous and cortical bone when employed as graft material At the very outset, it should be said that in regard to the behavior of the fully matured bony elements, whether they be derived from cancellous or compact bone, there is no great difference The mature bony elements once transplanted do not, for the most part, survive They constitute a mass which is so inert that it does not provide even a foreign body reaction, and sooner or later will be replaced by that process known as "creeping substitution" This process is exceedingly slow and extends over many months, with a gradually subsiding impetus In any graft, whether it be of cancellous or cortical origin the only elements which survive and which possess *osteogenetic* power in any degree, are the cells which form the so-called endosteal layer This is also true, but to a lesser extent, of the elements of the cambium layer of the periosteum Once these two fundamental features are appreciated, the relative merits of cancellous over cortical bone grafts become immediately apparent *

This thesis is born out by the outstanding researches of Bernard Steinberg of the Toledo *Research Institute*

Finally, it appears reasonable to say that from our clinical experiences with bone grafting, our knowledge of grafts other than bone certain experimental facts and reliable biophysiologic principles that any type of bone graft containing viable cellular con stituents may live if the strict conditions *necessary for its survival* are provided Since in actual practice the establishment of such conditions is particularly difficult with bone grafts because of their physical make up, a large proportion of them may act principally as physiologic splints and stimulants to ingrowth of new bone from the recipient bone ends The degree to which the latter needs to replace the graft de pends upon the amount and the maintenance of osteoblastic" viability in both the gen *eral condition of the patient and the other* factors cited heretofore

TYPES OF BONE GRAFTS

Bone grafts, like other tissues, may be divided into free and pedicle grafts The free grafts may be subdivided into osteo periosteal grafts, cortical, cancellous grafts corticocancellous grafts (C and C grafts) and full thickness grafts

The sources for bone grafts are many The main sources are the tibia, ilium, rib, calvarium and at times the other long bones of the extremities The choice of source is entirely dependent upon the type the quan tity and the nature of the graft necessary, as well as the location of the recipient site

During and since World War II the major source of bone grafts (particularly cancel lous) is the crest of the ilium Bone from this region is particularly desirable for

* Abbott L C, Scholtstaedt E R Saunders J B, and Bost, F C The evaluation of cortical and cancellous bone as grafting material, J Bone & Joint Surg 29 381-414 1947

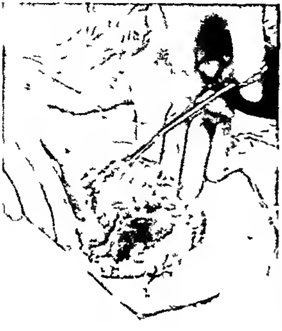


FIG 148 Iliac crest is exposed by incising fascia over crest and wiping gluteal muscles laterally and abdominal muscles medially The latter (iliacus muscle) is shown medial to wound depth after mobilization of large bone graft shown held above the donor site by hemostat (cf Fig 147)

restorations about the head the face and the hand It has many advantages over other sources excepting the rigidity of the crest of the tibia which is also the most easily accessible The crest of the ilium, although almost as easy of access, is a source of relatively large bone grafts which can be mobilized in any one of the types enumerated Being a bone the major portion of which consists of cancellous material and because it is already shaped by nature in curved fashion it is much easier to manipulate than the hard cortical bone from the tibia the femur or other sources A specific illustration where the choice of source of a bone graft is dictated by type of recipient site is the use of the last or floating rib for purposes of reconstruction of the thumb Its shape size and cartilaginous compound make it ideal for this purpose The same applies to the use of the contralateral iliac crest for total reconstruction of the mandible (see 'Jaws")

Indications for Bone Grafts

The indications for the use of bone grafts may be put succinctly by saying that where bone has been lost, only bone should be used for replacement The most common need for bone graft arises in connection with losses of the mandible in the restoration of mutilated noses, losses of frontal bone, loss in the zygomaticomalar region, the radius, or the ulna, bones of the hand and in spinal fusions In any condition where a bone graft is contemplated, one thing must be kept in mind and that is that rigidity of bone is one of its virtues which must not be disturbed if possible Consequently, all bony restorations must be planned in an architectural way When this is done it not only obviates interference with the function of the part but also makes tissue cost and shaping of the graft a much easier problem It means expert carpentry

Methods of Mobilization

Iliac Graft. The iliac crest, being the most common source of bone grafts particularly for losses of the skull and the face, is exposed by a two or three inch incision exactly to the outer edge of the crest starting from the anterior superior spine and extending backward If the incision is carefully carried through the fascial attachments of the abdominal and the gluteal muscles, it is then a simple matter to strip the former medially and the latter laterally without injury to the underlying bone or periosteum (Fig 148)

Wherever possible it is best to use the inner table of the iliac crest because this avoids interference with the attachment of the gluteal muscles to the outer table It is accomplished by simply separating the tissues overlying the inner crest of the ilium with a gauze covered finger to the extent and the depth consistent with the size of the graft necessary The iliac crest is then split with a suitable chisel or osteotome,

and a section of the inner table is removed with heavy cutting scissors or bone forceps If a *thicker graft is necessary as*, for example, in the total restoration of the mandible, the entire thickness of the iliac crest may be removed

Upon close inspection of the iliac crest it will be found that for the restoration of the mandible the most suitable graft is the *one taken from the crest opposite to the* lost mandible It so happens that the curvature of the iliac crest is such that when the mobilized graft is rotated through 180°, it resembles the shape of the mandible of the opposite side In other words, the anterior pole of a graft removed from the right iliac crest comes to approximate the position of the ramus of the left mandible whereas the posterior end of the graft comes to resemble the position of the body With little shaping, as a rule, the graft may be inserted

There may be considerable *oozing* post operatively from the donor site of the iliac crest, and it is therefore necessary to control it completely, sometimes with oxycell It is advisable to insert, for a period of from 24 to 48 hours the rubber sleeve of a cigarette drain, thus avoiding hematoma formation The only other precaution necessary arises during the stripping of the musculature from the internal table of the ilium Caution must be exercised to prevent perforation into the abdominal cavity

Tibial Graft The mobilization of an osteoperiosteal graft from the tibia is a relatively simple one An incision is made through the skin and the meager amount of subcutaneous tissue usually present over the crest A minimal dissection of the soft tissues to the sides of the crest is done, followed by complete exposure A thin sharp chisel or osteotome is inserted at the chosen point and driven to a depth of no more than 5 mm, which is usually the extreme of thickness of this type of graft The instrument is then projected to a point consistent with the length of the bone graft necessary The same precautions as to postoperative hemorrhage and infection should be taken

FIG 149 Plan for composite graft (bone and soft tissues) for nasal defect, consisting of long sternomastoid tube whose distal peduncle is designed to carry with it part of the clavicle to reconstitute bone loss evident in nose (A somewhat difficult seldom used procedure)

in this case except that drainage is substituted by pressure dressings

Mobilization of bone graft, via electric saw, produces a periosseous coagulum responsible for the loss of many bone grafts It is not advised

Rib Grafts Basically, the mobilization procedure of a rib graft is the same as that used for obtaining cartilage from the chest cage Usually, removal of one of the "*floating* ribs" is *adequate* and *preferable* to removal of any other

The incision is made over the rib selected, carried down to the periosteum, which is carefully stripped, and the bone is removed by bone clippers *If it is desired* to remove a section of rib with its periosteum, the overlying soft tissues are gently stripped from its surface so as to cause no injury or laceration Sections of two or three ribs may be removed if neces-

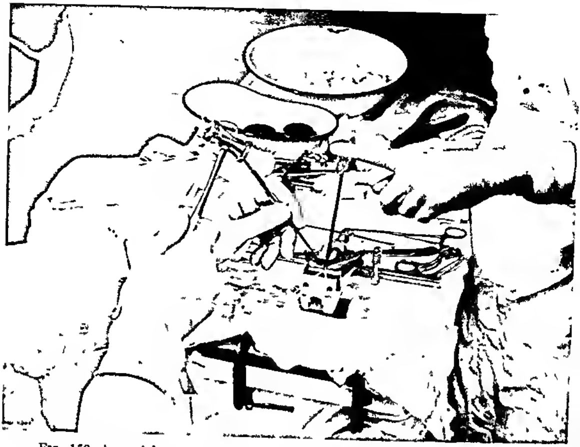


Fig 150. A special operating-room arrangement for shaping of bone grafts. In this instance a large section of the iliac crest is being shaped for total replacement of right mandible Assistant's hemostat rests in angle of new mandible, securely anchored in small vise

sary However, in my opinion, it is better to remove one entire rib, where much bone is needed

Clavicular Grafts. The clavicle may be looked upon functionally as a "spare tire" Its total removal interferes little with the shoulder girdle Occasionally, it is used as a graft, particularly for reconstruction of the malarzygomatic compound or the mandibular symphysis The technic of removal is basically the same as that used in extracting rib grafts It may be "carried" in part to various regions of the face as an integral part of a sternomastoid tube. This is not recommended for routine use. Such complex grafts are both difficult to make and to manage (Fig. 149).

Calvarial Grafts. Bone grafts are mobilized from the calvarium, as a rule, only in special situations. Only the outer table is used for purposes of the repair of defects in other locations of the part.

Methods of Fixation

Before a bone graft can be fixed into position it must be properly and as nearly perfectly shaped as is consistent with the size and the shape of the defect. Unless only cancellous bone is used which can be cut with heavy scissors, it is best to set up a small vise into which the potential graft can be inserted and in which with safety it can be shaped and modeled to the desired form (Fig 150). The vise should be set on a separate working table with all the instruments necessary for the shaping of

the graft, these are set aside especially for the purpose, which is better than transferring instruments from the operating table to the working table and back again The entire working table must be set up sterilely, as is done with any instrument tray, and the vise and the instruments are sterilized in a group for this special purpose The table should be located so that the surgeon can remain near the operating table and by simply turning on his stool go to shaping the bone graft

This is both expeditious and technically necessary where, during the shaping of the graft, the latter must be given several trial runs to the recipient site to test its fitness Walking across the operating room in such instances is both dangerous and poor aseptic technic

One detail of precaution in connection with the use of a metal vice must be kept in mind the lips, being of metal, are liable to fracture the bone graft unless they are toothed or padded with several layers of gauze, rubber or some other material which provides a certain amount of cushioning when the vise is turned down on the bone graft

Once the bone graft is properly shaped, it may then be drilled in predetermined places for insertion of wire sutures or screws, as the case may be Where bone pegs are to be used in place of screws or wires, as is preferred by the author, one must make certain that the holes drilled will be absolutely consistent with the diameter of the bone pegs intended The bone pegs do not necessarily mean additional mobilization of bone but, as a rule, can be fashioned out of such bone as is cut away from the graft in the shaping and modeling This detail is only possible where cortical bone is used This manner of fixing bone grafts is not only a fine piece of carpentry but actually a biologically preferable procedure

Once the bone graft has been properly shaped and drilled, it is ready for implantation Before proceeding with this step one should again make certain that all scar tissue and foreign bodies, such as clots and eburnated bone, are removed before the graft is laid To fail in this detail is to sacrifice a large percentage of successes in bone grafting Obvious and imperative as this oft repeated and homely detail is, it is amazingly neglected In fact, this phase of bone grafting is as important as the accurate mobilization and shaping of the graft itself, if not more so In connection with shaping the bone graft, Orr concludes that

> One point upon which the present writer has been engaged for many years and which has apparently not been taken into consideration by many operators is that the fitted graft has contributed so much to anatomic restoration not only of the bony structures, but of the surrounding soft parts When a bone graft is used to approximate and immobilize fractured fragments the adjacent nerve blood vessel, lymph channels and other parts are hooked into the best position and maintained in the best relationship for physiologic function in the entire part or extremity Such a contribution is of great importance to the patient s defense against infection and his recovery *

The manner of fixation of the graft to the recipient sites is sometimes a matter of predilection and at other times is dictated by the shape and the positions of the recipient bone ends It is mainly a mechanical problem and a matter of good carpentry

A bone graft can be immobilized in its recipient bed by suture, tendon, wire, screw, plate or bone pegs The choice of material and its manner of insertion must answer the problems of maximum stability, position and survival, as well as a minimum of irritation, foreign body reaction and tendency toward postoperative hemorrhage Of course, the ideal method of insertion, wherever possible, is to fix the bone graft by some type of slotting (Fig 151) This is

* Orr, H W The history of bone transplantation in general and orthopedic surgery, Am J Surg (N.S) 43 547 552 1939

accomplished by dovetailing the graft into the recipient bone, or vice versa, whichever seems more appropriate and promising This is preferable because it increases surface contact between graft and recipient bone and no drainage should be instituted Where a wound originally was of such nature that drainage was obviously to be a part of the surgical procedure, grafting must be excluded

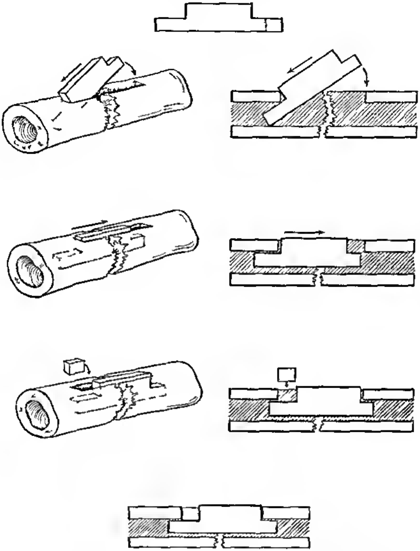


FIG 151 The 'latch' graft (Peter Cyrus Rizzo and Otto Lehmann) Method of slotting of bone graft (For purposes of illustration, the relationship of cortex to medulla is somewhat exaggerated)

to a maximum and is the best guarantee against dislocation of the graft

Having once fixed the graft in position, absolute collateral hemostasis must be secured, no foreign material such as sulfa powders should be dusted into the wound

POSTOPERATIVE CARE

Aside from the routine, postoperative care of the patient, the most imperative factor in bone grafting is foolproof postoperative splinting and fixation of the entire grafted part.

Many devices from plaster of Paris to complicated mechanical atrocities have been devised, depending upon bolts, screws, bars and wheels which, although they look impressive, are often so complicated and inaccurate that they utterly fail in their primary objective—*unyielding fixation* Certainly any method of fixation which involves perforation of tissues, particularly the bone ends near the graft, is ipso facto unphysiologic and dangerous

According to H Winnett Orr

> Many failures of bone graft procedures have been observed in which too much reliance was placed upon fixation and control of grafts too small or plates inadequately applied After operation, too, limbs are often imperfectly controlled in plaster of Paris or other splint devices *

It must be obvious by this time that bone grafting has its own special problems as well as privileges, but to be consistently successful one must absolutely observe certain vital principles

Criteria of Success in Bone Grafting

1 Method of mobilization must be as atraumatic as possible and consistent with need, physiology and asepsis

2 Choice of bone graft must be consistent with anatomic and functional need of injured part as to cortical and cancellous content

3 The manner of fixation of the graft must answer in every way the problems of survival, stability and position as well as guarantee against irritation, infection, hemorrhage and collateral tissue intrusion

4 The graft must be of such size, shape and structure as to allow total circulatory communion with its bed, as soon as possible

5 The recipient bed must be absolutely free of all fibrous tissue, present evidence of profuse circulation, with collateral tissues in adequate position and under normal tension

6 The splinting of the grafted part should be simple, yet guarantee maintenance of all physical and anatomic conditions of the graft and its bed

For use of bone grafts, in specific conditions, see Section III

ARTERIAL GRAFTING

The grafting of blood vessels, and particularly arteries, though of imperative interest and immense surgical consequence, is, for the present an unsolved problem Recent experimental indications as well as clinical trials on human beings, are most promising

Practically nothing in this respect had been accomplished by surgery until Alexis Carrel and Guthrie showed some years ago that fresh arterial grafts could be transplanted from one animal to another Following their work, isolated instances of the successful free transplantation of arterial segments had been reported by other investigators, Levin and Larkin, Hufnagel and Blakemore and Lord, and others Consistent success had not been attained by any worker in this field because of the paucity of knowledge apropos the maintenance of tissue viability before and after implantation The factor of immunologic reactions involved in transplantation and the lack of appreciation of the importance of meticulous technic necessary in tissue transplantation, remained as consistent impediments to success These basic and imperative criteria, so *indispensable to success in any form of* transplantation, were dwelled upon extensively in Section I of this volume

In the face of the lack of success in blood vessel grafting, many substitutes for blood vessels have been used Among these are silver tubes lined with paraffin, tubes of aluminum, of glass, of gold, or ivory, vitallium and, most recently, tubes of lucite None of them have proven physiologically adequate

* Orr, H W The history of bone transplantation in general and orthopedic surgery, Am J Surg (N S) 43 547 552, 1939

Gross Bill and Pierce of Harvard have recently reported a contribution to arterial grafting which seems like the most promising step accomplished thus far Their work is based on both animal and human trials Apropos the three basic necessities mentioned above appertaining to the grafting of any tissue they have first of all worked out a method of preserving arterial segments 3 centimeters in length, through storage of vessel grafts at temperatures just above freezing and immersed in a mixture consisting of 10 per cent homologous serum in a balanced salt solution to which is added a buffer a pH color indicator and penicillin with streptomycin The balanced salt solution is a modification of Tyrode s solution prepared according to J H Hanks The vessel segments were removed from animals mostly dogs within six hours after death and stored in the above solution up to 42 days before successful transplantation into other dogs The *crucial test of human application remained*

As a result of the fact that 22 out of 25 dogs who had their abdominal aortas ingrafted and who remained alive with blood coursing through the grafted aorta for periods of from four days to ten months the authors secured segments of arteries and aortas from human beings who died suddenly without any history of sepsis The authors stored these segments in the same manner as the experimental sections taken from dogs and subsequently implanted them into recipient human patients for the purpose of bridging gaps in large arteries This has been tried on 15 human subjects so far who the authors state have given results seemingly very promising Of the first 9 patients operated upon 7 cases at the time of the report were alive for periods *ranging from 7 weeks to 6 months* and improving whereas 2 cases expired the autopsies showing no disruption or failure of the grafted aorta

If this work is substantiated by others it will be an immense contribution

BIBLIOGRAPHY

Abbott L C Schottstaedt E R Saunders J B and Bost F C The evaluation of cortical and cancellous bone as grafting material J Bone & Joint Surg 29 381 1947

Altman H and Trott R H Muscle transplantation for paralysis of the radial nerve J Bone & Joint Surg 28 440 1946

Armstrong C J The use of a composite graft in reconstructive surgery of the lower eyelid Plast & Reconstruct Surg 3 9 1948

von Axhausen Med Klin 1911 p 1801

Bancroft F W and Pilcher C Surgical Treatment of the Nervous System Philadelphia Lippincott 1946

Barnes R Bacsich P Wyburn G M and Kerr A S A study of the fate of nerve homografts in man Brit J Surg 34 No 133 1946

Bergmann E and Krida A Asceptic necrosis and bone drilling Arch Surg 44 81 1942

Billig H E Muscle reinnervation J Internat Coll Surgeons 7 457 461 1944

Blair V P Some observations on our war experiences with face and jaw injuries Mil Surg 47 3 9 1920

Blocker T G Jr Cancellous bone grafts to the jaw Surg Gynec & Obst 84 No 4A 1947

Bothe K T and Davenport H A Reaction of bone to metals Surg Gynec & Obst 74 231 1942

Brown D Survival of cortical bone after bone grafting Brit M J 1 389 1946

Brown J B and Cannon B Composite free grafts of skin and cartilage from the ear Surg Gynec & Obst 82 253 1946

Brown J B Cannon B Graham W C Lischer C E Scarborough C P Davis W B and Moore A M Direct flap repair of defects of the arm and hand Preparation of gunshot wounds for repair of nerves bones and tendons Ann Surg 122 06 715 1945

Brown J B and McCarthy DeM Establishing a preserved cartilage bank Plast & Reconstruct Surg 3 283 1948

Brown J B et al Further reports on the use of composite free grafts of skin and cartilage from the ear Plast & Reconstruct Surg 1 130-134 1946

Bunnell S and Boyes J H Nerve grafts Am J Surg (N S) 44 64 75 1939

Burian F Vyber Nahradni Tkane Pro Obnovu Pevnych Podkladovych Časti V Obličej Zvlastni Ohsk Z Rozhledu V Chirurgii C slo 8 —Tiskem Knihtiskarny Typus Praha XVI Holečkova Ul ce 35

——— Quelques notes sur les transformations

de l'autogreffe cartilagineuse Extrait de la Revue de chirurgie plastique n° 1 mai 1934
Carpenter G K Advances in bone graft surgery attributed to World War II Surg Gynec & Obst 84 765 68 1947
Carpenter G K et al Restoration of bone strength with reinforcement bone grafts Bone & Joint Surg 28 692 1946
Carrel A J A M A 51 1662 1908 J A M A Aug 1 1912 p 523 J A M A Nov 11 1911 p 1611
Chandy J The fate of preserved heterogeneous grafts of fascia when transplanted into living human tissues Surg Gynec & Obst 83 145 1946
Cohn T Die peripherischen Lahmungen Berlin Urban & Schwarzenberg n 24 1927
Colonna P C Bone grafting methods Two illustrative case reports Ann Surg 125 96 101 1947
Corbett J F Internat Abstr Surg Feb 1919 p 105
Cutler N L Fascia lata transplant for retrotarsal atrophy of upper lid following enucleation Am J Ophth 29 1 6 179 1946
D'Aubigne R M Traitement des pertes de substance des nerfs peripheriques J de chir 62 292 305 1946
Davis J S Ann Surg Nov 1916 p 519 Feb 1917 p 1 0 Bull Johns Hopkins Hosp Oct 1911 p 3 2
Davis J S and Hunnicutt J Ann Surg June 1915 p 672
Dupertius S M Actual growth of young transplants in rabbits Arch Surg 43 32 1941
Firestone C Boiled cartilage implants Am J Surg 72 153 1946
Gillies H D Plastic Surgery of the Face Oxford Med. Pub 1920
——— St Barth Hosp J May 191 p 9
Gordon S The role of cancellous bone in plastic surgery Surgery 20 202 1946
Graham W C and Risdon D Sublimis transplant to restore abduction of index finger Plast & Reconstruct Surg 2 459 1947
Gross R E Bill A H Jr and Pierce E C Methods for preservation and transplantation of arterial grafts observations on arterial grafts in dogs report of transplantation of preserved arterial grafts in 9 human cases Surg Gynec & Obst 88 689 1949
Gurdjian E S and Webster J E Diagnosis and management of peripheral nerve injury Am J Surg 74 359 36 1947
Hamlin E Jr and Watkins A L Regeneration in the Ulnar Median and Radial Nerves Surg Clin of North America Mass Gen Hosp No Philadelphia Saunders 1947
Hellstadius A A Study of New Bone Formation Provoked by Subperiosteal Injections of Blood Plasma Extract of Bone Marrow etc Acta Chir Scandinav 95 Fasc I II 31 53 1947
Henderson M S and Henderson E D Bone grafts for ununited fracture of the neck of the femur J Internat Coll Surgeons 9 26 35 1946
Hermann L G Management of injuries to large blood vessels in wounds of violence Am J Surg 74 360 3 5 104
Horwitz T and Lambert R G Massive iliac bone grafts in the treatment of ununited fractures and large defects of long bones the combined bone graft metallic plate technique An analysis of 91 operations in 85 patients Surg Gynec & Obst 84 435-450 1947
Hudack S S Blunt J W and Darby E K A study of bone matrix Am J Surg 74 5 9 585 1947
Jianu J Arch f klin Chir 102 Nr I 1913 Trans Internat Cong Med London Sec iu Gen Path Anat Pt 2 p 249
Kanavel A R Trans Am S A 34 434 1916
Kazanjian V H Spontaneous regeneration of bone following excision of section of the mandible Am J Orthodontics 32 242 1946
Kirkland G K Leontiasis ossea Brit J Surg 29 4 1941
Kirklin J W Murphey F and Berkson J Suture of peripheral nerves factors affecting prognosis Surg Gynec & Obst 88 19 1940
Konig F Deut med Wchnschr 36 Nr 4 1910 Arch f klin Chir 95 Nr 2 1911
Lambert C N Bone grafts (Surgical Clinics of North America Chicago Number) Philadelphia Saunders 1949
Lamphier T A and Littler J W Tendon transplants for radial and ulnar nerve paralysis Am J Surg 74 431 439 1947
Lathrop F D Facial nerve surgery in the European theater of operations Laryngoscope 56 665 1946
Leopold I H and Adler F H Use of frozen dried cornea as transplant material Arch Ophth 37 268 1947
Lexer E Arch f klin Chir Bd 95 827 1911 Ann Surg Jan. 1912 p 137 Kor Bl d allg arztl Ver v Thuringen Jena 1912 xli 389 Archiv f klin Chir 98 Nr 3 Klin Therapeut Wchnschr 1911 Nr 3
——— Weiderherstellungs Chirurgie Leipzig Barth 1920 p 360
Lichtenstein M E Acute injuries involving the

large blood vessels in the neck, Surg, Gynec & Obst 85 165 175, 1947
Littler, J W Free tendon grafts in secondary flexor tendon repair, Am J Surg 74 315 321, 1947
Loeb, L The Biological Basis of Individuality, Thomas Springfield Ill, 1947
Lord J W Jr and Breidenbach, L The management of acute traumatic arterial emergencies (Surgical Clinics of North America, New York Number) Philadelphia, Saunders, 1948
Macey H B A new instrument for passing portions of tendons and fasciae latae, Am J Surg (N S) 47 686 1940
MacFee W F Arterial Anastomosis in War Wounds of the Extremities Surg Clin of North America N Y Number, Philadelphia, Saunders 1948 pp 381 389
Magitot, A Pro Med June 1, 1912, p 364, J A M A July 6 1912, p 18
May H and Spann R G Cutis grafts for repair of incisional and recurrent hernias (Surgical Clinics of North America, New York Number) Philadelphia Saunders, 1948, p 517
Morestin H Bull et mem Soc d chirurgiens de Paris 41 1994, 1915, Bull et mem Soc d chirurgiens de Paris 42 424, 1916, Bull et mem Soc d chirurgiens de Paris Feb, 1917, p 580
Morestin, H, Villard E, Ulmann, Lexer, and Carrel A J A M A May 16, 1914, p 1581
Mowlem R Bone and cartilage transplants Their use and behaviour Brit J Surg 29 182 193 1941
McNealy R W, and Lichtenstein, M E Injuries and aneurysms of the vessels of the neck, J Internat Coll Surgeons 10 No 4, 1947
New G B and Erich J B A method to prevent fresh costal cartilage grafts from warping, Am J Surg (N S) 54 435, 1941
——— Bone grafts to the mandible Am J Surg (N S) 43 153 1944
Ollier L Traite experimental et clinique de la regeneration des os Paris 1867
Orr H W The history of bone transplantation in general and orthopedic surgery, Am J Surg (N S) 43 547 552 1939
Peer L A Experimental observation on the growth of young human cartilage grafts Plast & Reconstruct Surg 1 108-112, 1946
Penn J Jankowitz J and Bruwer A A note on the use of grated cadaver cartilage Plast & Reconstruct Surg 3 228 229 1948
Phemister, D B Internat Abstr Surg April, 1914, p 333
——— Changes in bones and joints resulting from interruption of circulation, Arch Surg Part I, 41 436, 1940, Part II, 41 1455, 1940
Pickard, E W Repair of bone loss and fractures of the face and mandible with cancellous bone chips, Canad M A J 57 556, 1947
Pollock, L J, Golseth, J G, Mayfield, F Arieff, A J, Liebert, E, and Oester, Y T Spontaneous regeneration of severed nerves, J A M A 134 330, 1947
Prigge, E K The treatment of chronic osteomyelitis by the use of muscle transplant or iliac graft, J Bone & Joint Surg 28 576, 1946
Prudente, A Free muscle transplantation in the restoration of lips and cheek, J Internat Coll Surgeons 7 312-314, 1944
Roche, M B, and Jostes, F A Ectopic bone deposits A paraplegic complication, Am J Surg 75 633 636, 1948
Searcy, H B, Carmichael, E B, and Wheelock M C The production of fibrous tissue around the fibers of cotton and other foreign material implanted subcutaneously in rates, South M J 37 149-150, 1944
Seddon, H J, Young, J Z, and Holmes, W The histological condition of a nerve autograft in man, Brit J Surg 29 378-384, 1942
Sheehan, J E The use of iliac bone in facial and cranial repair, Am J Surg (N S) 52 55, 1941
——— Application of epidermic skin and mucous membrane grafts to congenital and acquired states, M Rec 152 404-407 1940
Shumacker, H B Resection of the clavicle, with particular reference to the use of bone chips in the periosteal bed, Surg, Gynec & Obst 84 245 248, 1947
Simeone, F A The Anastomosis of Severed Arteries by a Nonsuture Method Surg Clinics of North America Mass Gen Hosp No Philadelphia Saunders, 1947, pp 1088 1099
Steinberg, B, and Hufford V Development of bone marrow in adult animals, Arch Path 43 117-126, 1947
Steindler, A Tendon transplantation in the upper extremity, Am J Surg (N S) 44 260-271, 1949
Straith, C L, and Slaughter, W B Grafts of preserved cartilage in restorations of facial contour, J A M A 116 2008, 1941
Stuck W G The preparation of autogenous bone grafts with osteotomes, Am J Surg (N S) 51 350-352, 1941
Tarlov, I M, Hoffman, W, and Hayner J C Source of nerve autografts in clinical surgery Technic for their suture, Am J Surg 72 700 1946

Thomson, J L, et al Plan for the care of peripheral nerve injuries overseas, Arch Surg *52* *557*, *1946*
Tuffier, I Bull et mem Soc d chirurgiens de Paris **36** 589 592, 1910
Wertheimer, P D'Aubigne, R M and Dejardin L Reparation des pertes de substance traumatiques des troncs nerveux des membres Association française de Chirurgie XLIXe Congres français de Chirurgie, Paris 1946
Wilson, P D Experiences with a bone bank Ann Surg **126** 932 1947
Yesipova, I K Histology of a nerve graft four months after operation, Am Rev Soviet Med *4* *37* *39* *1946*
Young, F Cast and precast cartilage grafts, Surgery **15** 735 1944
——— Homogenous cartilage grafts Surgery **17** 616 1945
——— The use of autogenous rib cartilage grafts to repair surface defects in dog joints Surgery **7** 254 1940
——— Autogenous cartilage grafts Surgery **10** 7, 1941

18

The Surgery of Scars

The formation of scar tissue consequent upon any type of trauma is a biologic inherency of most living things The lobster rarely scars he regrows a lost claw So far as man is concerned that biologic potency has been lost with the exception of the epidermis Were it not for the formation of scar tissue there would be no such thing as the healing of wounds, since that is nature s only method of obliterating tissue voids in man

The responsibility of the surgeon lies in the avoidance of excessive formation of scar tissue on the one hand and knowing how to deal with scar infiltrated tissue on the other This is particularly important to the plastic surgeon who is routinely called upon to remedy the defects resulting from the formation of too much scar tissue or its presence in situations adverse to adequate function In fact scar tissue is inimical to both form and function

In spite of its pre eminence, the scar remains a biologic enigma It is a surgical nuisance No class of cases is more consistently and effectively bungled than one where the surgeon has to deal with a scar per se The reason is simple The problem of the scar is still considered an elementary one in surgery and therefore, is attempted by any surgeon or is relegated to the inexperienced hands of the interne In any case, the results are surgical junk (Fig 152)

NATURE OF SCAR TISSUE

To deal adequately with a scar one must understand the nature of scar tissue It is nature s only biologic defense against an injury too extensive for primary or orderly healing It is a pseudophysiologic tissue with perverse innervation, inadequate circulation, poor construction and negligible qualities of repair Physiologically, it is a biologic foreign body Surgically, it is a tissue iceberg, two thirds of which is usually buried below skin level with tentacles reaching in all directions Its external appearance too often belies its surgical implications It may harbor within it most valuable structures as well as the potentialities of malignancy

Whenever the orderly, normal cellular structure of an organ is upset by any form of trauma, the injured area becomes essentially electronegative Due to physical derangement of the architecture of the part, an outpouring of serum and fibrin appears within a few minutes If the trauma is sufficient, whole blood will appear in the wound A coagulum results which acts as a temporary protective mechanism for the uninjured remains of the part After about 70 hours there is a proliferation of fibroblasts which continues until the fibrin has been replaced by connective tissue Depending upon the nature of the injury as well as the tissues involved, the connective tissue then becomes infiltrated by blood vessels or even by nerve fibrils This continues until the scar tissue is completely organized or contracted to a point where further ingrowth of vital tissues becomes impossible The scar then becomes a permanent part of the architecture of the injured region A certain amount of activity continues within the scar tissue for an indefinite time The essential clinical feature thereafter is the contraction of the tissue As a result of this

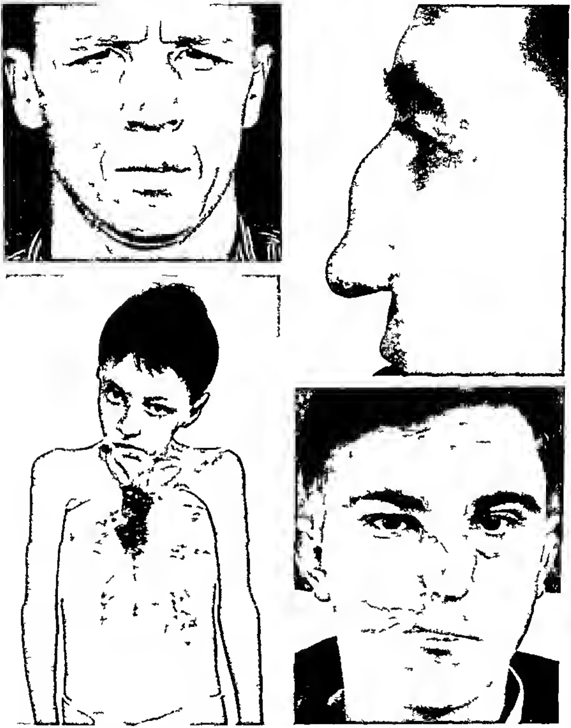


Fig 152A Surgical junk (the result of poor original repair or inadequate care) (*Top left*) The deformed nose with twisted septum and major obstruction (poor original repair) (*Top right*) The humped nose with drooping tip and receding lip (careless submucous resection) (*Bottom left*) The distorted human form (inadequate surgical care of burn wound) (*Bottom right*) The deranged middle face (superfluous original repair rotation of cheek flap to nasal defect a destructive procedure)

Fig 152B Surgical junk (*Continued*) (*Top*) The grafted malignant ulcer (an error of missed diagnosis) (*Bottom*) The deforming hypertrophic scar (due to forced suturing instead of split grafting defect Reconstruction now necessary via suprascapular tube shown) Even so when tube is spread into defect its edges must be approximated in serial Z plasty to avoid fiddle-string pull over neck region

secondary metamorphosis distortive effects are produced upon tissues collateral to the scar which eventually lead to some type of deformity It is this influence of scar tissue upon its surroundings which makes it a problem of great importance from the standpoint of plastic surgery

TYPES OF SCARS

For our purpose scars may be divided on clinical grounds into epidermic atrophic hypertrophic and neoplastic Under the last heading are included the keloids This restricted subdivision of scars is more easily understood and remembered It is basic from the clinical and the surgical as well as functional standpoints The commonly listed subdivision of scars into minimal extensive flat, indurated sclerosed and a legion of other names does not seem to the author to subserve any useful function but only confuses the student

Epidermic Scars

The epidermic scar results from a superficial injury involving only the outer layers of the skin It is essentially of esthetic consequence and rarely results in any functional implications (Fig 153) It is in short the scar of abrasions In its histologic implications it is comparable with the second degree burn

Atrophic Scars

The atrophic scar is unstable It usually results from relatively large or full thickness losses of tissue where healing occurs by secondary intention and final cicatrization Outwardly it is a thin appearing scar with a poor circulation and subject to constant solution and ulceration Its atrophic character is essentially the result of poor neurocirculatory integrity and a high degree of collagen formation within the involved tissues The slightest amount of friction or injury results in breakdown of the epithelial covering of the scar This is usually followed by infection which is difficult

FIG 152C "Surgical junk" (*Continued*) The "frozen" hand (due to splinting in extension and delay in grafting burned dorsum)

FIG 152D "Surgical junk" (*Continued*) The deformed hand (Poor original treatment of hand with unduly delayed reconstruction Latter inadequate when planned, as shown in photograph Flap should have been planned to cover entire scarred area of thenar and wrist regions When a flap of necessary dimensions is not available at chosen donor site, the latter should be abandoned and another sought, or the flap applied only to selected peripheral area of scarred defect Where it is buried within center of defect as shown above, it is imbedded contrary to principles governing preparation of recipient sites and often has to be completely sacrificed in replanning of adequate reconstruction This entails unwarranted tissue cost

FIG. 152E. "Surgical junk" (*Continued*). The contracted hand (due to ill-advised incisions of infected hand).

to eradicate (Fig 154). It is an unstable form of healing and almost universally interferes with the function as well as the use of the part

These scars are comparable with the third-degree burn, associated with loss of subcutaneous tissue In connection with this type of scar there is usually considerable atrophy of collateral and underlying tissues from both the pressure of the contracting scar itself on the tissues, as well as its interference with normal function. Because of this, the scars should be remedied as soon as possible lest they interfere with the circulation of the part, which then makes grafting difficult, since the grafts have to be placed into inadequate beds If this is not done, sooner or later contractures develop which further impede the function of the part and thus may ultimately destroy its over-all usefulness or make total rehabilitation impossible (Fig. 155).

Hypertrophic Scars

Hypertrophic scars should not be confused with keloids The former, although raised above skin level, never attain the size, distinctive architecture or the activity that the latter do. The raised hypertrophic scars have an atrophic epidermis, formation of collagen bundles in the papillary and subpapillary layer and a flattened epidermiodermal junction They are often transitory scars which, in due course of time, undergo spontaneous regression unless constantly irritated or infected. They may go on through a stage of quiescence to the formation of the atrophic type of scar. The hypertrophic scar, in contrast with the atrophic scar, is much softer and movable and does

not produce the fixation and the distortion of underlying and collateral tissues Where such scars appear on exposed parts of the body or in places where irritation is un avoidable it is best to remove them Com plete removal of these scars in contrast

Fig 152G Surgical junk (Con tinued) The genesis of fiddle string contractures (ill advised incision of right popliteal region)

Fig 152F Surgical junk (Con tinued) Carcinoma of burn of 31 years standing

with keloids usually results in a cure For details of management see the section on Surgery in this chapter (Fig 156)

The hypertrophic scar from the stand point of traumatic genesis is comparable with the atrophic type and therefore with the micropathology attending a third degree burn The difference between the be havior and the appearance of the two types is due to the fact that whereas in the atrophic type quiescence and involution are its pattern in the hypertrophic type hyper plasia and subjective symptoms such as burning pain and itching are not uncom mon The latter is due to cellular inclusion of epithelial remnants of histologic entities from the subcutaneous tissue such as the sweat glands These are comparable with a similar condition found in certain third degree burns The posttraumatic activity of these cellular inclusions viz sweat glands

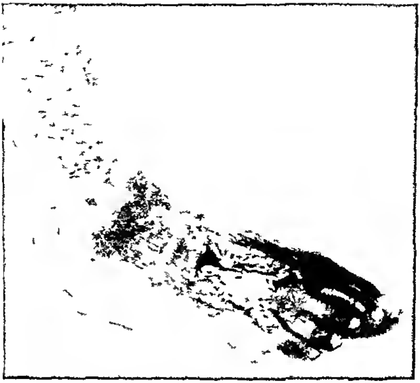


FIG 152H "Surgical junk" (*Continued*) The 'frozen" foot (poor original repair and neglected wound closure by free graft)

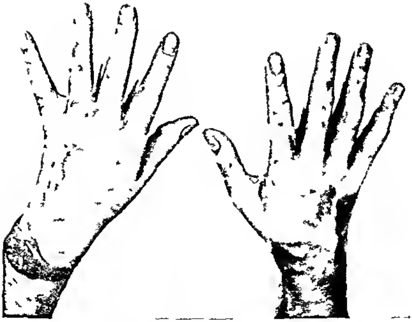


FIG 153A The epidermal scar Healed well managed essentially second degree burns of hands (Negro) Note conservation of skin detail loss of pigment, noninterference with function and beginning of repigmentation within burned area, especially marked on right hand

and their isolated activity when body temperature is raised, produces the periodic itching in hypertrophic scars In contrast with the atrophic scar, the hypertrophic type is essentially the result of a high degree of neurocirculatory activity and a low rate of collagen formation within the injured tissue

Neoplastic Scars

Foremost among neoplastic scars are the keloids They were first precisely described by Alibert in 1814 as, ' Shellfish With Processes Like Legs Implanted Into the Skin The name was derived from the Greek, meaning 'claw '

Keloids are benign proliferative, fibrous tumors arising in the subpapillary plexus of the cutis leading to a raised circumscribed shiny, hard, smooth, hairless growth which when it attains a certain size may remain in that state or eventually grow to unsuspected proportions One of the outstanding clinical features of the keloid is the abrupt transition from the tumor to the surrounding tissues (Fig 157)

Numberless theories have been put forth to account for their genesis One theory of causation held as most likely by many modern writers is the hormonal hypothesis *There is some support for this in the fact* that spontaneous resolution frequently occurs in keloids after the menopause, and also in the rarity of keloids in the old and the prevalence of keloids in the young

Paraffinomas should be included under the heading of neoplastic scars, although there is initially no involvement of the skin and therefore no clinical evidence of scar tissue The picture is, nevertheless, one of gradual and protracted scar formation consequent upon the absorption and the amalgamation of the paraffin with the fatty tissue under the skin, leading to irritation and ingrowth of fibroblasts and eventually resulting in subcutaneous scar formation With the passing of time this may eventuate in neoplastic or malignant proliferation

Fig 153B The epidermal scar (*Continued*) Healed essentially epidermal steam burn (outlined) Thick infrapatellar scars due to secondary injury

The paraffin acts as a foreign body and, if injected immediately into the skin or intradermally, will definitely result in scarring of the skin itself, if not early ulceration

Other neoplastic scars are such as present true, malignant changes microscopically classifiable as epidermoid carcinomas, sarcomas, or the so called Marjolin ulcerations (Fig 156) These are usually old atrophic constantly irritated scars which, through repeated breakdown, infection and protracted healing, *finally result in unmanageable*

FIG 154 The atrophic scar (*Top*) Postamputation scar Note flat, smooth transition of scar into skin Also contracting quality and tension of scar tissue These are the unstable, deforming scars (*Bottom*) Postincisional atrophic scar due to forcible closure with recurrent breakdown, ulcerated and infected Note deforming tissue tension

ulcerations in which neoplastic tissue proliferation takes place For treatment see the section 'Surgery' in this chapter

PHYSICAL THERAPY

In many cases, before surgery is decided upon, it is well to assist nature by massage, passive motion, and treatment by X rays and radium in the softening of the scar tissue (The latter should be attempted only by a highly experienced roentgenologist) This may involve the expenditure of considerable time but in certain cases constitutes intelligent preoperative treatment in that it accomplishes two things frequently necessary in very old scars which have involved, to a major degree, the collateral tissue Such preoperative treatment relaxes and softens the scar so that eventually a noticeable change may occur in its integrity The improvement of the quality of the scar tissue may permit eventual use of at least part of it in ultimate reconstruction Secondly, the relaxation and the softening of the scar allows for gradual improvement of the part, so that sudden release after excision does not result in complications such as fracturing of bone, dislocation of a joint injury of a major vessel, or the laceration of a nerve

The greater one's experience with scars, the more inclined one is to take them seriously It is a good policy to take the same surgical attitude toward them as one does toward a benign neoplasm From the standpoint of the plastic surgeon, it is sound principle to insist upon complete and thorough elimination of all scar tissue before doing any repair This ideal, of course, is not always possible because of the amount of scar tissue, its position, the state of its organization or lack of normal tissue for replacement in the repair In such instances, as indicated heretofore, scar tissue itself may have to be prepared for actual use in the reconstruction of defects

Personally, I think it is an admission of surgical defeat to have to use scar tissue in

repair, but at times circumstances leave no alternative Under such conditions one is forced to collaborate with a potential enemy

SURGERY

Indications for Removal of Scars

Scars must be removed because they interfere with function or they are painful or they appear on exposed areas of the body, or they are disfiguring, or because malignant change has taken place within their confines

Anesthesia

Local analgesia is not always adequate during the excision of a scar This is due to two reasons (1) the diffusion rate of novocaine in scar tissue is exceedingly slow and inadequate, (2) the analgesia does not reach the sympathetic innervation of the blood vessels within the scar These, upon section, result in so called ' blood vessel pain " Consequently, in extensive scars either a block or general anesthetic may have to be employed The choice of general anesthetic must depend entirely upon the general condition of the patient and the nature and the extent of the scar which is to be removed

Don ts in the Surgery of Scars

Where one is forced to operate upon a scar tissue

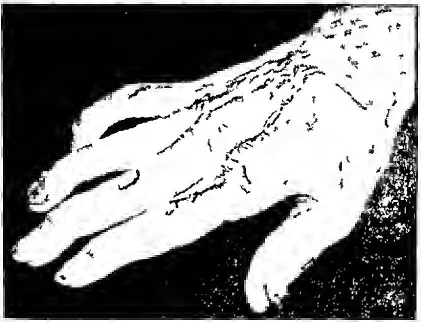


Fig 155 The atrophic burn scar The dark patches are areas of pigmentation

(1) Don t operate unless fully conversant with its kind and content

(2) Never operate too early

(3) Never operate too much

(4) Always prepare an extensive scar beforehand by proper physical therapy

(5) Always operate cautiously

(6) Always remember that with old scars there is distortion of collateral tissue, viz, the shortening of muscles, tendons, blood vessels, nerves, bowing or fragility of bones, displacement of joints and other structures, so that sudden release of the scar tissue may result in serious complications or consequences

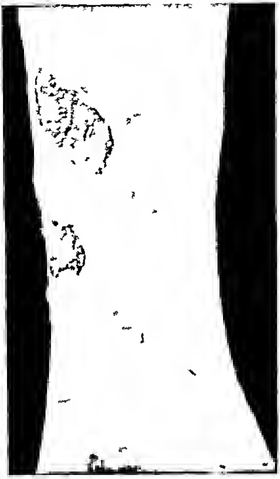


FIG 136 The neoplastic scar Note proliferation of edges and nodular appearance of old granulation tissue particularly near edges of ulcers Biopsy disclosed early neoplasia in these nodules as well as in the ulcer edges Radical section of all skin and scant subcutaneous tissue was done on back of leg and temporary thin split grafts applied while large thoraco abdominal tube was being readied for the extremity Implantation of tube should be done only after 6 months and re biopsy

Foremost among the foregoing is the matter of operating on scars too early There is one exception to cautioning against early operation on scar tissue On the principle that a scar is only made worse by constant stretching and definitely improved by relaxation if scarring then takes place in a location where it is by normal function constantly tensed or irritated it is better to do an early simple Z plasty or transsection at the point of greatest tension with free grafting of the surgical defect It is nothing more or less than the age old practice of our predecessors of cutting across a scar to release the pull with the obvious advantage of free grafting and avoidance of more scarring The relaxation will not only avoid functional aberration of the part but eventually will result in a softer more pliable and at times even useful scar

Types of Operative Procedure

The actual operative procedures upon scar tissue itself may be divided into scar revision partial excision complete excision with primary repair transsection of the scar with free grafting of the surgical defect partial or complete excision of the scar with inshifting of collateral tissue and finally the replacement of the scar tissue by other tissues brought in from a distance in the form of pedicles

Scar Revision

Where a scar has shown decided improvement as a result of physiotherapy its functional implications can often be resolved if the scar is not too extensive by so-called tissue revision This consists in certain planned geometric incisions of the scar tissue itself This implies the so-called Z plasty V Y plasty and other forms of revision These procedures are not always as elementary as they may seem offhand Therefore the surgeon must be thoroughly conversant with what is required of these procedures as well as their limitations

The Z Plasty

Since the Z plasty is one of the most frequently employed procedures in the revision of scars it will be described here in sofar as it applies

With the scar under tension the proposed incisions are marked out with 5 per cent cresyl green in alcohol The central line of

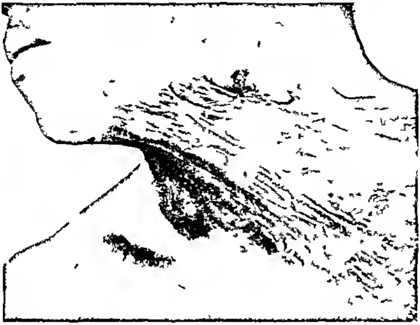


FIG 157 The hypertrophic scar (*Top*) Cervical scar following third degree burn Note thickness and yet comparative elasticity of scar tissue with a thin epithelial covering Also note lack of collateral tissue deformity which is more peculiar to atrophic scars (*Right*) Condition of hypertrophic cervical scar after partial excision Note tendency toward replacement by hypertrophy of suture lines This can be avoided in final scar excision by undermining and complete relaxation of collateral tissues Also observe reconstitution of neck form at this stage

the Z is drawn along the most prominent part of the web and the arms of the Z which are of the same length are laid out parallel to each other at the ends of the central line on opposite sides at about a 60° angle to the central line thus making an atypical Z or reversed Z depending on the condition of the surrounding tissues The 60° angle between the central and the projected arm lines of the Z has been found to be the most satisfactory angle for practical use but angles between 60° and 20° can be used depending on the elasticity of the tissues, on the thickness of the flaps essential to viability the location of the contraction and the contour of the part (Fig 159) If unequal angles are used, the arm lines will r arallel

FIG 158 The keloid (*Top*) Keloid in Negro, the result of collar button irritation (*Bottom*) An unusual circumferential keloid in white male arising from suture line about thick split skin graft The latter can still be seen in center of keloid Note two smaller keloids on shoulder, result of towel clip perforations at time of operation Observe highly organized appearance and precise edges of lesions, as contrasted with hypertrophic scars

When the incisions are made following the marked-out "Z" pattern, two triangular flaps are formed These flaps are mobilized, binding scar tissue beneath is removed, and all bleeding is checked. The extremities of the central incision then draw away from each other by retraction, the central line becomes longer, and the angles become blunted. The flaps are then transposed and sutured without tension so that their outer margins are in approximation and their tips touch the corners of the bases of the opposite flaps The sutured wound is also "Z"-shaped, but the "Z" is turned through roughly 90°, is elongated, and the central line of the original "Z" now lies transversely across the line of scar pull. For further discussion of this subject the reader is referred to Chapter 21, "Surgical Geometrics"

PARTIAL EXCISIONS

Where complete excision is not practicable or possible, repeated partial excisions of scar tissue are done. Where this is done in old, organized and avascular scars the excision should be made along the border of the scar. Notwithstanding the recommendation by some authors to do excisions routinely from the center of the scar, this is not consistent with physiologic facts, and the practice cannot be supported by experience As indicated heretofore, scar tissue is a pseudophysiologic entity. Hence, if excision is made from its center, the result of the closure must be based upon the inescapable fact that both lips of the defect consist of abnormal tissue. Clinically, this is substantiated by a relatively large percentage of postoperative breakdowns and secondary hypertrophic scar formation, which occurs in such cases. This is unavoidable since pseudophysiologic tissue cannot enjoy normal healing and result in normal scar formation If, on the other hand, excisions are made from the periphery of the scar, at least one of the lips of the surgical wound consists of normal skin which is

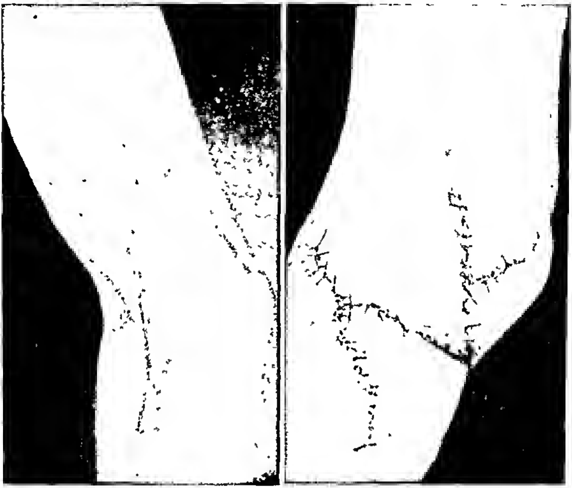


FIG 159. "Z"-plasty of antecubital "fiddle string" scar (*Left*) Preoperative (*Right*) Postoperative Tissue repair well planned, suturing shows signs of haste.

able to supply the badly needed circulation in the healing process following closure. A much smaller number of postoperative breakdowns will be met with in this type of procedure Hence, the importance of knowing the quality of the scar before deciding on the method for its eradication

If the excision is made from the periphery, the same quantity of scar, or more, can be removed as with a central excision This is accomplished by the planned bilateral excisions as illustrated in Figure 160 This procedure is particularly adapted to scars whose polarity is parallel with the lines of Langer. Almost invariably the original scar mass is divided in due course of time into two or more smaller scars which with the attendant skin relaxation can be removed at one time

Where the scar obviously has a fairly good intrinsic circulation, there may be an advantage in excising a block of its center and thus avoiding repeated small invasions of the good collateral skin, which is the only major objection to the latter procedure (Fig. 161).

TOTAL SCAR EXCISION

The ideal form of scar ablation is by total excision and primary closure of the surgical defect. This is not always possible or practicable, as indicated heretofore; but

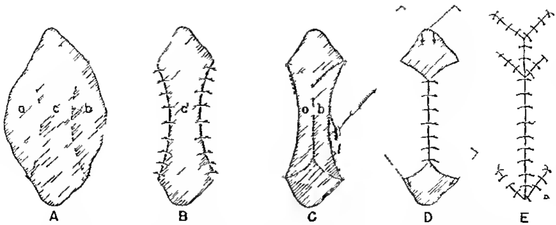


FIG 160 Planned excision of scar (A) Areas a and b are excised at first sitting leaving area c for subsequent excision Dotted areas show extent of undermining for closure (B) Closure after excision of a and b in A (C) Scar C is then excised by removing a or b or both at one time depending upon actual size of areas and elasticity of collateral skin This leaves the two extremities of scar C to be removed subsequently as shown in D (D) Optional plans of closure of polar defects remaining after final scar eradication Choice of incisions indicated depends upon skin elasticity and relation of scar to collateral tissues or organs such as the eye ala or corner of mouth (E) Final appearance of closure suggested in D

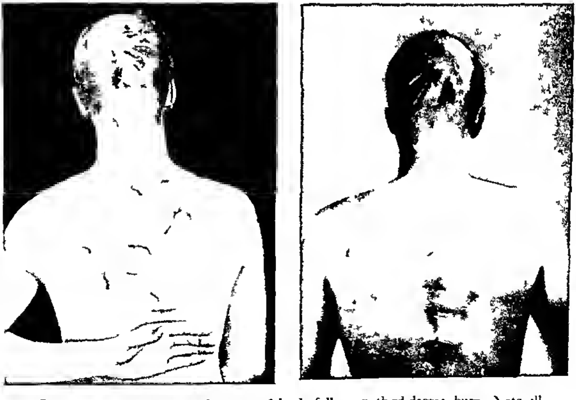


FIG 161 (*Left*) Hypertrophic scar of back following third-degree burn Note ill advised attempt at patch grafting into body of scar (*Right*) Same case following repeated (4) partial excisions of scar At this point only isolated small areas need excision to complete the task The long linear portions of the scar are actually atrophic suture lines

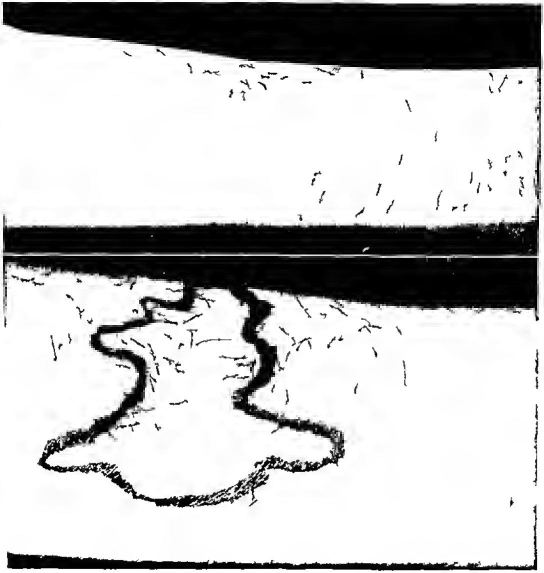


FIG 162 Atrophic scar of forearm To avoid obliteration of scar outline and to permit accurate excision the scar should be outlined with aniline dye Incisions always should be *made outside outline Lower photograph somewhat magnified to show skin details*

where it can be carried out certain preliminary precautions should be taken in order to avoid surprises or failures First of all one should make certain that the best possible operating room lights are available This is even more important in dealing with scar tissue than with normal tissue To miss certain detail ramifications of a deep scar, which then remain in the lips of the wound is to do a closure by inserting suture material into scar tissue unknowingly Such sutures usually cut through in the process of healing or set up focal cellular reactions which eventuate in a beaded wound

With the area well illumined it is good practice to outline carefully all the skin ramifications of the scar with one of the aniline dyes such as brilliant green (cresyl green) or methylene blue (Fig 162) This avoids distortion of the scar as well as of the collateral tissue during the excision The latter can thus be carried out with greater

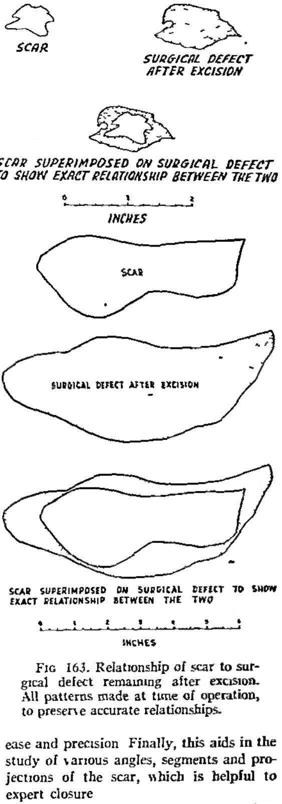


FIG 163. Relationship of scar to surgical defect remaining after excision. All patterns made at time of operation, to preserve accurate relationships.

ease and precision Finally, this aids in the study of various angles, segments and projections of the scar, which is helpful to expert closure

Having once outlined all the ramifications of the scar, one must consider the collateral tissues as concerns lines of tension, disturbance thereof and displacements. Thus one can arrive at some idea as to the shape and the extent of the resultant surgical defect after excision. This is important. One of the greatest surprises to the neophyte after excision of a scar, say one inch in width and two inches in length, is the resultant defect which may be three inches in length and two and one-half or more inches in width, with all types of unexpected angulations and tissue retraction (Fig. 163). It can be put down almost as an axiom in the surgery of scars that the surgical defect remaining after excision will be at least 30 per cent more extensive than the original area covered by the scar itself. In actual practice the surgical defect is often 50 or 100 per cent, or even more, in over-all extent than the area involved by the scar.

This brings up the important fact that total and complete scar excision almost invariably establishes a surgical defect at least equal in area to the original wound Frequently, the defect is even greater than the original wound because of tissue retraction and surgical undermining necessary for relaxation. Finally, it is a practical fallacy to assume that when the scar tissue is excised, one will only reproduce the original area involved by the trauma. It must be remembered that in the healing of the original wound a certain amount of scar infiltration in the periphery of that wound has taken place. This must be included in the excision of the visible scar. Hence, the ultimate surgical defect to be anticipated will not be only 50 per cent more extensive than the surface of the scar, but at least 10 per cent larger than the original wound. In other words, whereas the scar may have been two and one-half square inches, the final surgical defect after complete scar excision probably will be at least four square inches (Fig. 164).

With the foregoing in mind, one is better prepared for the exigencies of scar surgery.

This should be done as meticulously as the excision of a neoplasm The scar tissue should be firmly grasped by a reliable instrument, such as a toothed forcep, accurately circumincised through the derma so *that no ragged skin edges are created*

Since hemostasis is rather difficult io scar excision the excision should be carried out under constant suction In this manner the fine line of cleavage between the scar tissue and its environment can be kept under direct vision and all of the deep ramifications of the scar can thus be cleanly dissected out It will be found after some practice that a much cleaner and more accurate excision can be done if one learns the 'cleavage" method of dissection as described in Chapter 12, The Surgical Process' in the sections on incisions and types of dissections By this means one can learn to 'feel" the difference between scar tissue and normal tissue through the blade of the scalpel Incidentally it is much better to dissect normal tissue away from the scar rather than to try to dig' scar tissue out of its environment

The surgical wound remaining after the extirpation of an extensive scar is a very interesting one The depths of such a wound are usually not smooth and symmetric or what one might call a handsome wound Instead, due to the extirpation of the many scar ramifications, large tags of deep tissue will have been left here and there viable and useful, although they could be excised, they may be very serviceable in the repair of the surgical defect They often fit into recesses where wound apposition by suture is difficult

One of the great problems in the closure of a wound remaining after extensive scar excision is what to do with the depths of the wound Wound closure followiog scar excision presents two important geometric problems One is the closure of the various segments of skin, and the other is the adequate repair of the depths of the wound The latter can usually be remedied only by

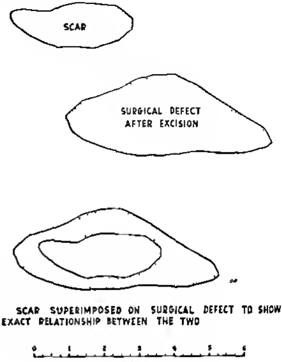


Fig 164 The scar and its surgical defect

the inshifting of subcutaneous tissue This can be reduced to a minimum through the conservation of such tissue as can be left behind by meticulous extirpation of the scar alone Not to secure the depths of the surgical defect properly is simply to end up with a depression defect These depression defects sooner or later call for secondary operations which can easily be avoided at the time of the original excision

Finally, in complete one stage excision of extensive scars attention must again be called to the fact that the ramifications in depth may not only be tentacles about innocent tissues, but they often include vital structures, such as large blood vessels or nerves Therefore, it is all the more important that only scar tissue be removed and that it be done so meticulously that no normal inclusion structure is overlooked or injured Where such structures are present and their import is absolutely essential to the function of the part, and where it is

Fig 165A A contracture of neck following third degree burn Patient found it extremely difficult to swallow and to control saliva A simple transection of scar and extension of chin was done as an expedient so patient would gain comfort preliminary to further reconstruction (Fig 165B) Major reconstruction at this time was out of the question because with such acute flexion of neck, any kind of prolonged anesthesia was difficult Note bilateral ectropion with ulceration of right lower lid Also observe breaking down of scar tissue over shoulders a common complication of old burn scars Typical atrophic scar

physically impossible to dissect the structures away from the scar tissue, under such circumstances it may be necessary to leave tags of scar tissue attached to them This is one of the rare excuses for ever leaving any scar tissue behind

Transection of Scar Tissue

One of the oldest practices in the surgical management of scar tissue always has been to cut across its fibers where the scar was most binding This practice has been almost totally abandoned in the past decade or two for the reason that a large open wound was created in a pseudophysiologic tissue which took a long time to heal and finally resulted in still more scar tissue if not actual keloid formation With the advent of early wound closure by means of skin grafting this old practice can in principle be recalled into practice as a serviceable measure in selected cases because with the immediate grafting of the transection the wound is closed and the great objection to the old practice is dis-

FIG 165B As a temporary expedient to basic function a simple transection of the scar was done followed by sufficient undermining to allow head to be extended The incision was free grafted Patient had immediate relief (1 month postoperative) In the interim both lower lids were free grafted to resolve ectropion There is still some eversion of outer one half of left lid unavoidable in this case because of difficulty in maintaining tarsorrhaphy due to severely damaged lid margins as well as deeper lid tissues Note rapid healing of shoulder ulcerations following cervical grafting The concomitant release of collateral tissues allows for the healing

pensed with (Fig 165) In other words where no raw area is left no scar tissue will re form As with the old method the part is relaxed and function is restored

Where the surgical defect following transection of a scar is obviously an avascular sclerosed bed and further improvement of the bed cannot be attained by more extensive transection or deeper dissection the defect can still be closed by simply rotating a so called French flap from the collateral tissues across and into the scar so that immediate closure can be attained In fact this latter procedure is a far better and a more nearly ideal method of immediate repair of scar transections than free grafting It often proves to be a permanent partial repair of a scarred defect whereas the use of a free split skin graft is often only a temporary expedient of little actual reconstructive value Wherever collateral tissue is available for rotation flaps it is good practice to plan scar transections with that in mind particularly where two or more

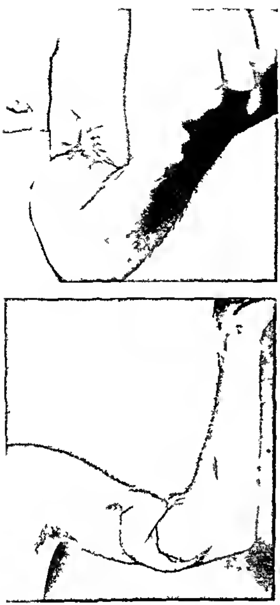


Fig 166 (*Top*) Extensive deep scar of arm and elbow (gunshot wound) necessitating immediate complete removal because of neurocirculatory interference Tissue must be imported to cover surgical defect left after excision (*Bottom*) Scar has been excised, with tube graft partially opened to cover surgical defect Further spreading of graft to be done as case permits to accomplish complete extension of extremity Sudden extension of long contracted joints must be avoided in certain cases because of danger of overstretching nerves and blood vessels (See text)

flaps can be thrown across a binding scar at the same time because what scar tissue eventually remains between the flaps can often be excised later with direct approximation of the edges of the flaps This results in complete functional restoration of the part without further complicated and protracted migration of tissue into the defect

Excision with Ingrafting

Where total scar excision with primary closure, partial excision or transection with free grafting or inshifting of collateral flaps is not possible, yet complete excision is imperative tissue must be prepared first in the form of flaps or tube pedicles at a distance This must then be migrated into proximity to the scarred defect in preparation for its imbedding into the surgical defect consequent upon excision This type of situation is not rare in extensive scarring of the head, face, neck hands, feet or the lower third of the leg (Fig 166)

Scar Decapitation

As noted heretofore one of the two great problems following total excision of scars is the adequate reconstruction of the depths of the resultant surgical defect This is not always an easy matter Particularly is this true in parts of the body where collateral deep tissues are at a premium, too vital to be used for filling in the defect, and where tissue would have to be imported in order to accomplish the desired result

Hence many authors recommend the excision of merely that portion of the scar which projects above the level of the subcutaneous plane It is then recommended that the lips of the skin edges be undermined and brought over the remaining scar tissue (Fig 167) In other words, the deep portion of the scar remains in the depths of the wound The problem of what to do with the depth of the wound is thereby circumvented This practice is not recommended by the author simply because it is only a

makeshift for functional repair One of the essential reasons for the removal of a scar is to improve function, and so long as any scar tissue remains in the depths of a wound, complete function never can be ultimately realized In such cases it is recommended that the scar be completely excised and the skin closed in so that it lies snugly against the depth of the wound, even though this results in a temporary surgical defect, a depression It is better in such cases to be satisfied with the need for a secondary operation consisting of the implantation of subcutaneous tissue in the form of fat, cartilage, fascia, derma or bone which can at a later date be insinuated under the skin This point is emphasized here simply because some textbooks on general surgery leave the impression that scar 'decapitation' is good routine practice From the standpoint of the plastic surgeon especially where it concerns the matter of facial expression, the glaring fact remains that so long as any scar tissue remains in the substance of the part, detailed function is improbable

Total Scar Excision and Immediate Reconstruction

There are situations where, coincident with total scar excision, it is necessary that some degree of immediate reconstruction of the part be done This is particularly true in major injuries of the extremities and more so in the lower than in the upper extremity This has to do particularly with complex wounds of these parts, such as shrapnel or gunshot injuries involving not only skin and the remaining soft tissues underneath, but bone and joint as well The excision of all scar tissue would not only reconstitute a large original wound but also recreate the difficult problem of some kind of immediate closure In other words, the wound is so extensive, so deep and involves so many structures that secondary reconstruction would be inadequate if the wound were only free grafted or allowed to granulate before grafting Hence, coincident with total excision of scar tissue, the plan must include some degree of immediate soft tissue reconstruction

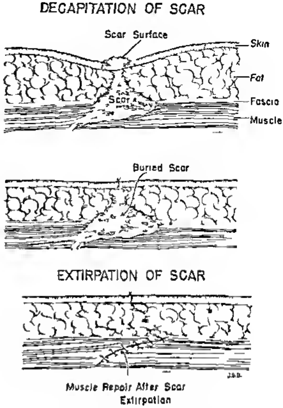


Fig 167 (*Top*) Scar decapitation a procedure which may be esthetically satisfactory but often functionally inadequate because scar (*center*) left in depths of wound acts as a biologic foreign body and a functional impediment (*Bottom*) Proper method of scar irradication (complete) permitting muscle repair and hence functional restitution Where scar does not involve fascial or muscular structures below the problem is a simpler one, and burial of scar may be chanced

The most expeditious method is that embodying the inshifting of neighboring tissues (See author's dermoplasties, Chapter 16, 'Skin Grafts and Grafting," also "Extremities") Although this is basically founded upon collateral incisions, it must not be confused with the so called relaxing incision whose exclusive purpose is to per-

mit skin closure The procedures referred to here (Chap 29 Lower Extremities) on the other hand have for their principal aim the immediate ablation of complex wounds and the establishment of proper tissue environment in depth for subsequent reconstructive procedures of an orthopedic or neurosurgical nature

The procedures consist of calculated and meticulous dissection of double pedicle flaps or both single and double pedicle flaps collateral to the surgical defect with shortening of the circumference of the ex tremity by mobilization of subcutaneous tissue from a secondary surgical defect thus allowing for the reduction of the latter sometimes to a point where it can be closed without any free grafting Where much tissue is needed in the depths of a wound the mobilized subcutaneous tissue or fascia of the secondary defect in the form of pedicled fat flaps can be transposed into the depths of the primary defect This not only fills in the latter but also establishes a good bed for eventual bone grafting

These more extended procedures into re gions collateral to the primary defect are as a rule not resorted to where only simple scar removal is desired but are employed in conditions where underlying deep tissue deformities exist and immediate physiologic rehabilitation of the extremity is indicated due to gross circulatory embarrassment

POSTOPERATIVE CARE

Whenever the exclusive purpose of an operation is the excision of scar tissue whether for esthetic or functional reasons the ultimate good lies in the avoidance of more scar tissue This in large measure de pends upon the quality of postoperative care of the wound closure The ultimate aim must be complete tissue relaxation in and about the area of excision Where only the skin covering is concerned this can easily be accomplished by butterfly adhesive strips collodion tension strips or any other method which will guarantee no tension upon the suture line Where deeper tissues such as tendons blood vessels or periarticu lar tissues are concerned the entire ex tremity may have to be splinted in a position of complete relaxation Active movements must be guarded against until adequate healing has occurred This varies somewhat in different tissues With the ex ception of bone and tendon 12 days may be accepted as an average This must be followed by intelligent passive motion massage helio and hydrotherapy of a quantity consistent with the individualiza tion of wounds as well as patients (See Chap 19 Splints & Splinting)

BIBLIOGRAPHY

Blair V P and Byars L T Paralysis of the lower lid and scleral scars and grafts Surg Gynec & Obst 70 426 1940

Brown J B and Blair V P The repair of defects resulting from full thickness loss of skin from burns Surg Gynec & Obst 60 379 1935

Cannaday J E The application of the cutis graft to various types of reconstructive surgery J Internat Coll Surgeons 9 655 663 1946

Coventry M B and Beck N R Primary ten don suture J A M A 135 80 82 194

Davis J S The late plastic care of burn scars and deformities J A M A 125 621 1944

Ench J B Treatment of extensive cicatricial stenosis of the larynx or the trachea Arch Otolaryng 41 343 1945

Esser J F S Surg Gynec & Obst June 1917 p 45

——— Epithelial inlay for scars in the neck dragging the lower jaw downwards Am J Surg (N S) 45 148 149 1930

Gillies H D Plastic Surgery of the Face Oxford Med Pub 1920

Greeley P W Plastic repair of extensor hand contractures following healed deep second de gree burns Surgery 15 1 3 1 1944

Greeley P W Practical procedures for the cor rection of scar contractures of the hand Am J Surg 74 622 630 194

Johnson H M Congenital cicatrizing bands Am J Surg (N S) 52 498 501 1941

Kazanjian V H Treatment of deformity from burns Connecticut M J 8 661 1944

May Hans The correction of scars Am J Surg (N S) 50 54 60 1940

Morestin, H Bull et mem nat Soc de chir 41 1233, 1915, 42 2052, 1916

Rubin, L R Langer's lines and facial scars, Plast & Reconstruct Surg 3 147-155 1948

Smith, Ferris Multiple excision and Z plastics in surface reconstruction, Plast & Reconstruct Surg 1 170 186, 1946

Speranski, A D Posttraumatic contractures, Am Rev Soviet Med 4 22-24, 1946

Stern, E L A new operative procedure for Dupuytren's contracture, Am J Surg (N S) 54 711-712, 1941

Stevenson, T W Release of circular constricting scar by Z flap, Plast & Reconstruct Surg 1 39 42 1946

Straatsma, C R Surgical technique helpful in obtaining fine scars, Plast & Reconstruct Surg 2 21 24 1947

Straith, C L Facial scars, Am J Surg (N S) 36 88, 1937

Sutton, L E Reconstruction of contracted axilla, Plast & Reconstruct Surg 1 43 48, 1946

19

Splints and Splinting

The question of splints and splinting is one of the outstanding problems in surgery There are three main reasons for this First splinting varies not only from patient to patient in the same general type of defect but often in the same patient with the progress of healing and the augmenting of function The second and more important reason is that thus far there has been little standardization in the matter of splints and very little crystallization of the principles behind the phenomena of splinting as it applies to plastic surgery

The third and most important reason is that splinting is too often looked upon as a kind of nuisance in the surgery of repair This stems from the lack of appreciation of the dynamics behind the phenomena of splinting Too much stress is too often laid upon the material which is to go into the making of a splint and a single mechanical purpose which that splint is supposed to accomplish rather than what it must subserve under specific conditions of surgical pathology and the ever variable exigencies of progressive repair In other words apparently related conditions are made to fit a preconceived splint rather than a splint to fit a given problem in a given patient It is an adynamic perspective of a dynamic necessity The origin of such an attitude may be found in the outworn belief that the essential purpose of a splint is to throw an injured part out of action This logical necessity has been practiced to the point of unreasonableness in that injured parts are thrown not only out of action but also out of form A splint is good only in the degree to which it subserves functional rehabilitation and formative results A crutch is a splint Irrespective of its composition and basic intent if it does not permit the patient to walk and perchance incurs damage to his shoulder girdle, it is not a good splint

A splint is any medium which will countermand the effects of the law of gravity upon injured tissues as well as the displacement of injured tissues by those uninjured maintain the integrity and the selected relationship of tissues or protect the part from the patient for purposes of functional healing and formative results

Splints may be divided into two categories functional and formative To comprehend adequately the basic principles behind the phenomena of splinting one need only to realize that the entire question of locomotion as well as certain other functions of the body are based at least from a mechanical standpoint upon the phenomena of splinting Insofar as the anatomic relationship and the functional interplay between the bony muscular and covering tissues of the body itself involve the laws of leverage and the phenomena of splinting bones become the functional splints to their related muscles whereas the latter by reciprocal action become the formative splints of the bones joints or orifices to which they are attached

The phenomena of splinting never will be resolved in the student s mind adequately unless a more dynamic perspective of the splint is added to his thinking This dynamism is inherent within the body construction itself and to a large degree determines the quality of function and the degree of form

From the formative standpoint, splints may be divided into orthopedic and esthetic From the functional standpoint, they may be divided into prosthetic and kinematic splints (Chart 5) Ultimately, any splint is only a medium which either conserves or re stores form and function

The basic purpose of an orthopedic splint is the restoration of form whereas the purpose of an esthetic splint is the con servation of form The basic purpose of a prosthetic splint is the conservation of function, usually through maintenance of muscle balance and integrity The essential and final purpose of the kinematic splint is the restoration of function

This dynamic subdivision of splints, for instance, is in contrast with the adynamic quality of the long used Banjo splint and is also contrary to its principle To quote Bunnell, The Banjo type of splint should be condemned, the straight pull on the fin gers in extension leaves them stiff and also results in malunion of fractures' * In other words the adynamic position of the digits leads first to the lack of functional restitu tion and ultimately to aberration of form The end result may be chronic invalidism

In the designing of splints one should first make certain as to what relationship exists in a given case between the deformity and the dysfunction The same deformity in two different individuals does not neces sarily produce the same degree of dysfunc tion The purpose of the splint must always be expeditious resolution of the two toward early rehabilitation After construction or establishment of splint action, the test of validity resides in the reconciling of both form with function In other words, the form of the hand in a Banjo splint remains irreconcilable with the purpose of the part, therefore, functional rehabilitation remains problematic Finally, where a part is splinted in form, even healing may be compromised

* Bunnell, S Surgery of the Hand, Philadelphia, Lippincott ed 2 1948

TYPE OF SPLINTS†

Orthopedic (Anatomic)

The essential purpose of an orthopedic splint is the restoration of form, therefore it is well represented by such things as sutures dressings, nails and screws, plaster of Paris boards, rods, interdental appli ances, Asch s tube the Balkan frame, Stent molds atropine interdental wiring mat tress sutures and others

Esthetic (Formative)

As indicated heretofore the essential aim of esthetic splints is the conservation of form There are numberless varieties of estheses represented by such diverse things as fascial slings used in facial paralysis dermic grafts or fat grafts used in the ob literation of shallow depressions tantalum plates used in the restoration of the form of the calvarium brassieres acrylic supports, tapes adhesives silver and gold inlays, cartilage inserts, essentially for purpose of support and the *attainment of form* ivory inlays mimicries (prostheses ') where the conservation of form is too difficult by other than artifact These consist for the most part of latex substitutes, such as artificial breasts, corsets, transformations and many others In other words where the question of restitution of form or appear ance is involved, an esthetic splint is indi cated It is the crutch of appearance

Prosthetic (Functional)

The prosthetic splint, since it has for its basic purpose the *conservation* of function, may be represented by such things as the lining of cavities, dental bridges, artificial cineplastic parts, obturators, vellums, su tures, intra oral prosthesis, the tarsorrha phy, braces (elastic), dermic grafts, pessaries, therapeutic shoes, *applications of cold*, and many others They are, one and all, "functional crutches" It will become

† Contrast Types of Splints with Categories of Form' (cf Chap 23)

SPLINTS

FORMATIVE

FUNCTIONAL

ORTHOPEDIC*	ESTHETIC†	PROSTHETIC*	KINEMATIC†
Sutures	Facial Slings (to muscle)	Pressure Dressings	Reading Glasses
Dressings	Dermic Grafts	Dental Bridges	Hearing Devices
Nails	Tantalum Plates	Artificial Parts (Cineplastic)	Transpl Tendons
Screws	Acrylic Supports	Obturators	Transpl Muscles
Plaster of Paris	Silver Inlays	Vellums	Contact Lenses
Boards	Gold Inlays	Sutures	Bunnell Splints
Plates	Cartilage Inserts	Intra-oral Prosthesis	Chatfield Splint
Cotton	Ivory Inlays	Tarsorrhaphy	Kazantian Splint
Collodion Paints	External Prosthesis	Braces (elastic)	Dental Plates
Rods	Rubber (Latex) Subst	Facial Slings (to fascia)	Vitallium Cups (Femoral)
Mechanic s Waste	Corsets	Dermic Grafts	Sauerbruch's Prosthesis
Interdental Appliances	Transformations	Pessaries	Gallbladder Tubes
Ascb s Tube	Fat Grafts	Tracheotomy Tubes	Heat
Joseph Nasal Splint	Opiates	Therapeutic Shoes	Surgical Substitutes
Wires		Cold	
Balkan Frame			
Stent Mould			
Interdental Wiring			
Mattress Sutures			
Atropine, etc			
Preformed Splints (Metallic and Plastic)			

PROSTHESTHETIC

viz 1 Tantalum repair of forehead with Tarsorrhaphy
2 Intra oral prosthesis with Latex nose

ORTHOKINEMATIC

viz 1 Tendon or Muscle transplant with Bunnell "pull out" suture, etc (see text)
2 Dental plates with Kazantian spring lever with jaw action

*Conservational
†Restitutional

CHART 5

obvious upon reflection that cold, like the dental bridge, is a splint particularly fitted for the conservation of function, whether it applies to a part or a cell

Kinematic (Dynamic)

The purpose of kinematic splinting is the restoration of normal function

When through the service of certain splints, a degree of function has been restored and form has been attained and restitution of normal use of the part seems to be possible, it may be augmented by further special splinting in the hope of eventual maximum rehabilitation Such splints are represented by reading glasses, hearing devices, transplantation of muscles or tendons, contact lenses, the Bunnell hand splint, the Chatfield splint, the Kazantian oral splint, dental plates, vitallium caps (femoral), Sauerbruch s prosthesis, gall bladder tubes, heat and others In other words, the surgical pathology and consequences following trauma may be of such degree that only conservation of function and form up to a certain level is possible Thereafter some type of functional coach' may be needed in order to augment the use of a part parallel with the needs of the rest of the individual These are the kinematic splints

Compound Splinting

In actual practice, of necessity, the issue is rarely the mere conservation of form or the restitution of appearance, nor is it sufficient to conserve what function is left in order to attain complete rehabilitation of the individual Therefore, it is necessary to combine within the structure of the splint the concept of both orthopedic and esthetic, or esthetic and prosthetic, or kinematic and esthetic qualities As a matter of fact, many of the substances and items enumerated above subserve a dual function when properly and fully employed (Viz Tantalum plates They may serve the function of protection by their presence, without conserving the form of the part unless properly used) This invariably results in modifications of basic splints so that by the inclusion of two or more of the formative or functional qualities they become what may be termed prosthesthetic or orthokinematic splints (Chart 5) Examples of a prosthesthetic splint would be an intra oral prosthesis to which is attached a latex nose, or a tarsorrhaphy in combination with a tantalum reconstruction of the frontal region An orthoprosthetic splint may be represented by a dental bridge to which is attached an appliance for a stent mould An orthokinematic splint is well represented in a case of polio paralysis by a tendon transplant secured for the time being by a Bunnell pull out wire suture and additional appliances coaching the tendon into function Ultimately, of course with the removal of Bunnell s pull out suture, the transplanted tendon would remain as a kind of biologic kinematic splint to the joint or the part to which it had been transferred

In a sense, the compound splint implies the splinting of a splint by another until maximum rehabilitation is attained It also establishes a concept of complexity in splints which only attains simplicity as the progress and the conditions of healing permit Experience bears this out When it is necessary to splint a grafted lid by tarsorrhaphy, both lids must be splinted by sutures until such a time as healing of one lid to another is established When this has occurred the sutures may be removed, thus reducing an orthoprosthetic splint to a simple prosthetic splint The latter is represented by the tarsorrhaphy which must then be maintained as a splint until complete organization of the grafted lid takes place This may take months The important thing to remember is that as adequate functional rehabilitation is approached, splinting becomes more and more simplified Splinting must not only be consistent with the progress of the case but, incidentally, is an indication thereof When final organization of

FIG 168 The suture splint Note aluminum buttons under lower lip Over these are tied wire sutures (No 36) whose distal loops are within the upper lip This establishes a temporary cheilorrhaphy until the triangular flap brought down from paranasal region has healed into position The sutures must be placed so that splinting does not interfere with feeding as indicated by open (left) one-half of mouth They can easily be left in situ for a week or more without injury to lower lip, unless tied too tightly

a reconstruction takes place, no splinting is necessary because the reconstruction becomes part and parcel of the anatomic form and function of the part and so becomes permanently and functionally splinted by the anatomic integrity of the whole

SPLINTING MATERIAL

The materials used in the accomplishment of splinting are legion and will not be enumerated or discussed in detail here because mention of them can be found in any textbook on surgery but a certain few will be discussed because they are seldom thought of as splints and rarely in terms of the principles of splinting

SUTURE

Foremost among these is the suture While in most other forms of surgery the suture is looked upon as a medium of simple wound closure, in plastic surgery it must frequently subserve the function of a true splint The outstanding illustration in the use of a suture as a splint is in the so-called "tarsorrhaphy," where the eyelids are sutured together for purpose of mutual support This same principle can be applied to the repair of all other orifices and particularly to the lips and occasionally the anus or the vagina (Fig 168) Where a repair is done, say on the injured lower lip, the lip can be approximated to the good mate by means of a judiciously placed mattress suture These sutures should be so placed that they subserve their function without interfering with the patient's ability to take some kind of food The same fundamental precaution applies here as it does in the use of mattress sutures for any other purpose They never should be tied tightly They can hardly be tied too loosely The splinting value of such a suture is obvious

HUMID COTTON

Another very useful material for splinting, particularly where fine tissue detail is involved, is humid cotton I have found no other material equal to it in the splinting of the damaged ear, whether due to a burn or other form of injury Most damaged ears can be saved from the fate of the cauliflower type, necroses and distortion by accurate immediate splinting with humid cotton Petrolatum jelly or other forms of oiled gauze are not adequate because they are difficult to pack into the detailed structure of the auricle and because they are even more difficult to keep in place

A sheet of cotton is laid out and sprayed with saline or sterile water It is then pressed dry with a rolling pin The cotton is picked up with forceps and packed bit by bit into the recesses of the ear It is then covered with dry gauze and bandage or adhesive This is a guarantee against postoperative edema, subcutaneous oozing and consequent deformities

Before packing the humid cotton into the contours of a tissue, it is well to cover the

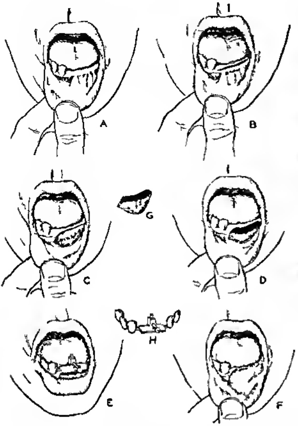


FIG 169 (*Left*) (A) Lower lip adherent to gum (B) Gingival mucosa incised (C) Lip separated from alveolus (D) Stent mold covered by skin graft inserted (Note G—stent mold impression of defect covered by skin graft) (*E*) Oral appliance (see *H*) in place securing skin covered mold (F) Mold removed Defect grafted Lip free Waldron Esser principle of splinting split free graft used as lining for labial sulcus (After Gillies) (*Right*) Illustrating a method of splinting split skin graft intended as lining for nose Nostril was opened wide by scar excision, impression taken of cavity with stent (shown riding on vertical bar of oral appliance), skin graft neatly draped over stent mold, inserted into nostril and vertical bar secured to dental appliance (See text for subsequent management)

part with one layer of Xeroform or petrolatum gauze After a day or two the cotton becomes dry and somewhat starchy If it is too wet at the outset, it may even become hard In severely injured tissues this hardness may result in pressure necrosis of the skin particularly if the bandage is tight Sufficient of the cotton must be insinuated into the convolutions of the tissue to more than fill the crevice This is necessary because as the humid cotton dries it shrinks In a few hours following the dressing, the cotton assumes the exact shape of the part If carefully removed at redressing time and laid aside without disturbing its shape, it can be replaced (covered with thin layer of petrolatum) to continue its original service after the part has been cleaned

For larger defects and grafts of any size the use of mechanic s waste as recommended by Blair and Brown is generally as adequate and somewhat less expensive It does not lend itself to the fine detailed packing of humid cotton, but is much easier to handle and serves the purpose very well in gross defects

WAXES

The splinting of skin within deep and complex cavities is best accomplished by waxes They may be paraffins, dental waxes or stent These are first melted then cooled and, while still moldable, they are insinuated into the depression and cooled against it or within it by ice water Upon their removal an exact impression will have re

Fig 170 Patient holding acrylic form constructed as pro tempore splinting of recently lined eye socket and lower lid reconstruction Note small hole in center of acrylic to allow for seepage from graft When grafted socket is completely organized and tendency to shrink has ceased (minimum of 6 wks), a permanent prosthesis may be inserted

sulted of the cavity to be lined The mold is then covered by an appropriate graft, which is usually secured about the mold by a few sutures in the edges of the graft and the entire composition reinserted into the depression (Waldron Esser technic) (Fig 169) After the lapse of a sufficient number of days, the wax or stent mold can be removed by cutting the sutures The graft will be found to remain as a lining within the defect or depression Since most materials of this type are much harder than the tissues about it the precaution must always be taken not to apply too much pressure when bandaging over them or necrosis of the graft will result

Acrylics

Where more durable material must be used because it is intended to remain for long periods of time as a postoperative splint, acrylics or metals are employed The former is rarely used as an external splint in the place of waxes, because it is relatively difficult to work with and to shape But in certain instances, such as intra oral splinting or that of a free grafted eye socket, it has few equals (Fig 170)

Tapes

If the student takes time to decipher the possibilities inherent in the proper application of tapes (adhesive, collodion strip, etc) he will be rewarded by an amazing variety of simple and inexpensive splinting procedures Their application is not easy to describe, because it takes considerable imagination or its counterpart, visual education, to be of pedagogic as well as practical consequence (Fig 171)

Miscellaneous

A legion of other material is often used in plastic surgery in one way or another to subserve the function of a splint Among these is plaster of Paris, rubber bands, Scotch tape, wires, bandages, catheters and even gravity itself The manner of their use has been discussed in previous chapters

CONDITIONAL SPLINTING

Conditional splinting denotes the protection of a completed repair, against the consequences of early use, by some form of graduated control

When sutures have been removed and before complete organization of the repair has taken place, conditional splinting is the only safety valve against abuse by otherwise normal excursion of a part This should be maintained until normal use of the reconstructed part can safely be permitted without danger to the integrity of the repair This may depend not only upon the degree of healing of the wound and organization of the repair, but sometimes upon the occupation of the patient or even his disposition

For the normal use of a part is a conditioned reflex

The commonest form of conditional splinting is elastic adhesive Strips are placed at right angles to the polarity of the repair, or in such a manner as to control the extent of permissible function, this function being determined by the condition of the reconstruction Adhesive is not always adequate material, particularly in summer, because it has a tendency to crease, to irritate and to loosen It must then be frequently removed or constantly watched, which may prove to be a nuisance A better method is to apply some form of elastic adhesive material and reinforce it with collodion if necessary The method of application is basically identical with that described in a foregoing chapter in connection with collodion strips

At this point the student must be aware of the fact that the nature of the material used in splinting is a secondary consideration in delineating its worth Its ultimate value resides in its purpose and mode of application The function that the material subserves determines its classification

Where conditional splinting of an incision or repair by adhesive or collodion strips is not possible, some surgeons paint the incision with compound tincture of benzoin and then cover the part with collodion From a mechanical standpoint this serves the purpose well, particularly in small repairs Occasionally, it leads to trouble The epithelium of the skin closure being still very young and easily traumatized may blister, desquamate and even ulcerate under collodion Finally, the complete sealing of a surgical incision with collodion produces a local anaerobic condition which, in the presence of certain bacteria and in conjunction with unhealed suture perforations, may lead to trouble

The use of conditional splinting need not necessarily be confined only to avoiding diastases of the unorganized closure, because of early use of the part With relatively well healed incisions, particularly those running horizontally with the ground, a closure is still subject to diastases (cheek, abdomen and buttocks) due to the pull of gravity upon the part when the patient is in the upright position The weight and the sagging of the tissues under such conditions may result in wide hypertrophic scars or even keloids It is, therefore, good practice in such cases to maintain conditional splinting of the parts for periods up to six weeks postoperatively and in exceptional cases even longer

Where the patient's occupation or temperament does not permit the continuance of conditional splinting for the required period of time, it is still recommended to the patient that it be used at such times as are consistent with his occupation or profession In other words where splinting is not possible during the day it may be applied in the evening or throughout the night After one or two trials on some other part of his body, the patient soon learns how to apply collodion strips In children it can be applied by the parents Where it seems to be difficult for the patient to grasp the procedure, it is not impossible for him to learn the use of elastic adhesive

Where adhesive or collodion strips are out of the question for one or another reason, some other form of material, such as Scotch tape, may be used, provided that it does not irritate the skin This can be readily determined by applying a strip to some part outside of the reconstruction and allowing it to remain from 4 to 6 hours If after that time there is no undue redness underneath the strip, it can safely be worn for the night If there are any signs of irritation under the tape, the probability is that the skin will blister

There are any number of so called skin glues on the market, most of which are designed to avoid irritation of the skin They are somewhat more difficult and complicated to use, but where there is no other

choice the patient must learn to apply these to the supporting strips or must make arrangements for their application by some one else A good example of another type of simple conditional splint is the adjustable brassiere advisable after radical mammaplasty

BIBLIOGRAPHY

Anderson Roger, and Erickson, H R Glass plastic cast Am J Surg (N S) 59 299 305, 1943

Aufricht G Dental molding compound cast and adhesive strapping in rhinoplastic surgical procedure Arch Otolaryng 32 333, 1940

Brown A M Correction of facial defects with latex prostheses Technic, Arch Otolaryng 35 720, 1942

Bunnell S Active splinting of the hand, J Bone & Joint Surg 28 732, 1946

Ceci A Procedes originaux d amputation plastico-cinetiques ou plastico orthopediques, J de chir et Ann Soc belge, de chir 7 132, 1907

Codivilla, A Protesi cinematica in un caso de disarticolazione del piede Bull Scienze mediche, Bologna 10 1910

Delprat G D Ankle strapping U S Navy Med Bull 39 564 1941

Eggers, G W N The contact splint, Texas Rep Biol & Med 4 42 1946

Eiselsberg Von Zeigt einen 33 Jahre alten Mann der ohne Prothese mit seinen (2) Arm stumpfen ausserordentlich viel leisten kann, Munchen med Wchnschr 64 256, 1917

Esser J F S Enabling useless thigh stumps to move a prosthesis J Internat Coll Surgeons 9 141 143 1946

Gordon D Traction splint for hand and fingers Am J Surg 74 747 751 1947

Gottlieb J J and Gottlieb M M A New Technique in Foot Appliance Construction, J Nat Assoc of Chiropodists Jan 1946

Horwitz T Opponens thumb wire splint, Am J Surg (N S) 58 460 1942

Ivy R H and Curtis L Recent experiences with skeletal fixation in fractures of the mandible J Oral Surg 1 296 1943

Kazanjian V H Immobilization of wartime, compound comminuted fractures of the mandible Am J Orthodontics 28 551, 1942

Kelley S B Ureteral Splints Surg Clin of North America Mass Gen Hosp No, Philadelphia Saunders 1947 pp 1312-1320

Lexer, E Weiderherstellungs Chirurgie Leipzig Verlag Von Johann Ambrosius Barth, 1920, p 360

Lambert, C N Plaster of paris technic for the application of casts (Surgical Clinics of North America, Chicago Number), Philadelphia, Saunders, 1949

Malimac, J W Compressive suspension splint for severely comminuted fractures, Plast & Reconstruct Surg 2 331 335, 1947

Mason, M L Purposeful splinting in injuries and infections of the hand Surg, Gynec & Obst 68 1 1939

Neviaser, J S Traction manipulation treatment of "stiff neck," M Ann District of Columbia 9 75, 1940

Overton, L M A simple foot plate for use in skin traction on the lower extremities, J Iowa M Soc 30 110, 1940

Owens, Neal A suggested pyrex form for support of skin grafts in the construction of an artificial vagina, Plast & Reconstruct Surg 1 350, 1946

Pick, J F An original operation for decubital ulcers J Internat Coll Surgeons 10 598 599, 1947

Quigley, T B, and Urist M R Interphalangeal joints, Am J Surg 73 175, 1947

Reese, J D Dermatape a new method for the management of split skin grafts, Plast & Reconstruct Surg 1 98 105 1946

Rubin L R, et al Polyethylene in reconstructive surgery, Plast & Reconstruct Surg 3 586, 1948

Smith, F Pressure bags for skin grafting Surg, Gynec & Obst 43 99, 1926

Stark, R B Pre operatively applied mated plaster of paris casts as an aid in the migration of open pedicle cross leg flaps, Plast & Reconstruct Surg 2 433, 1947

Strickland, J M Prosthetic restoration with a removable partial denture after surgical removal of a tumor of the right maxillary antrum, Am J Orthodontics 31 504-510, 1945

Weiner, H A new type of foot brace for the treatment of foot imbalances Am J Surg 44 663 664, 1939

Winter, L, Lifton, J C, and McQuillan, A S Embedment of a vitallium mandibular prosthesis as an integral part of the operation for removal of an adamantinoma, Am J Surg (N S) 69 318 324 1945

——— Suspension Traction Treatment of Fractures War Dept Technical Bull, TB MED 133 Jan, 1945

20

The Surgery of Burns and Their Consequences

The adequate care and functional rehabilitation of a person who has been severely burned is a task of great surgical magnitude It may well be expressed as follows *He who knows all there is to know about burns and their consequences knows most of what there is to know about surgery* The truth of this statement becomes self evident when one considers the physiologic the psychological the biologic and the nursing implications of severe burns *A severe burn stands out at once as the most formidable physiologic disaster and surgical tragedy known to medicine* A burn in contrast with other misfortunes of man is no respecter of tissue integrity kind size or nature of the organ All tissue will burn and burn alike There is no immunity resistance or total psychosomatic rehabilitation to burns

A severe burn is a physiologic disaster because the body can compensate permanently for such devastation only up to a point beyond which irremediable biologic changes result Whatever the biophysiologic consequences it remains a surgical tragedy because we as yet are impotent to remedy the more extensive destruction of bodily organs or parts such as the eyes genitals joints or the hands In other words though considerable physiologic compensation is possible too often there is too little in the way of surgical restitution One experience with the management of a group of severely burned people leaves the indelible realization of the physiologic gravity and the surgical magnitude of the problem (Figs 6A 12A Plates 3 4 7 and 8)

The U S system of burn identification as to degree is divided into first second and third degree and by a few authors a fourth degree burn is listed The French list burns to the sixth degree Personally the author feels that the French classification is surgically more useful for the simple reason that it is based on the principles of surgical pathology Since adequate surgery in a large measure is determined by surgical pathology the classification of Dupuytren seems more logical

According to the American classification a first degree burn terminates in erythema a second degree burn is attended by blistering (Fig 91) a third degree burn implies at least full thickness destruction of skin The authors who subscribe to a fourth degree burn include under this classification such burns as involve bone or joints According to the French (Dupuytren) classification a first degree burn is one of the epidermis a second degree burn one through the papillary layer of the dermis a third degree burn reaches into but not through the derma a fourth degree burn involves the subcutaneous tissue a fifth degree burn involves muscle and a sixth degree burn involves bone

Most burns are a mixture of degrees If one is in doubt a bit of epidermis may be scraped away or a small blister may be opened If the underlying derma is pink it is a second-degree burn If the derma is

gray in color, it is a third degree burn In the presence of charring, one is dealing with a third degree burn At times, only after the lapse of about 100 hours can one be absolutely certain as to the degree of a burn in any specific locality

Burns are further identified in terms of the percentage of body surface involved This may be estimated in several ways, but the quickest and most commonly employed is Berkow s method (Fig 171)

The scope of this book permits considera tion of only a small but important phase of the subject of burns—the surgical conse quences Even this must be qualified to ex clude internal emergency surgery, which more properly belongs to the domain of the general surgeon rather than to the sphere of the plastic surgeon

The surgery of burns may be divided into three parts (1) original, (2) late and (3) reconstructive

ORIGINAL SURGERY

The original surgery of burns has for its purpose the conservation of life, form and function It is accomplished in three stages (1) the physiologic management and gen eral care of the patient, (2) the biophysical care of the burn (3) the operative cure of the burn wound

Physiologic Management

The most important thing to do in a severely burnt individual is to treat the pa tient then the burn Aseptic and mechanical protection of the latter until the patient is safe is of course indispensable to ultimate rehabilitation

The physiologic treatment of the patient consists of proper and adequate sedation, maintenance of protein levels, prevention of infection infusions of plasma, whole blood and fluids and avoidance of renal, hepatic and pulmonary complications

Sedation In the sedation of severely burned patients certain basic physiologic disturbances must be borne in mind Anoxia is a common concomitant and is only aggravated by morphine Sensitivity to barbiturates is not uncommon, where such a his tory exists, they should be excluded in the management Codeine more commonly pro duces nausea and vomiting than is realized, and in burnt patients it will only increase dehydration In my experience, Pantopon up to 1 grain doses has proved to be the most reliable in all otherwise fragile cases

Since the advent of World War II, sev eral authors, among them Tovell, Barbour, Martin and R A Gordon, have been rec ommending intravenous procaine in 0 1 per cent solution up to 1 Gm There seems to be sufficient clinical evidence to justify its use although the pharmacology and the mecha nism of its peripheral action is not as yet well understood Since early use of intra venous fluids is indicated in burn treat ment the procaine can be given with the saline or the glucose, as the case may be It is particularly recommended during the initial dressing of burns

Protein Balance The maintenance of protein levels is not only important, but more imperative early in the burn crisis than after healthy granulations have ap peared It is not always possible by any means to maintain book values of serum proteins in severely burnt patients, but every effort must be made to keep as far as possible above the low norm of 6 0 Frequently this norm is the best attainable This can be accomplished in several ways, and all must be given consideration If the patient is able to take food per orum, one or another of the protein hydrolysate pow ders available on the market may be em ployed In some patients these can be relied upon to supply almost adequate protein intake In others this method is only sup plementary In still others, the protein hy drolysates produce gastric distress and hence cannot be employed at all

The most reliable form and source of protein supply is plasma via the intra venous route, particularly in the first 52

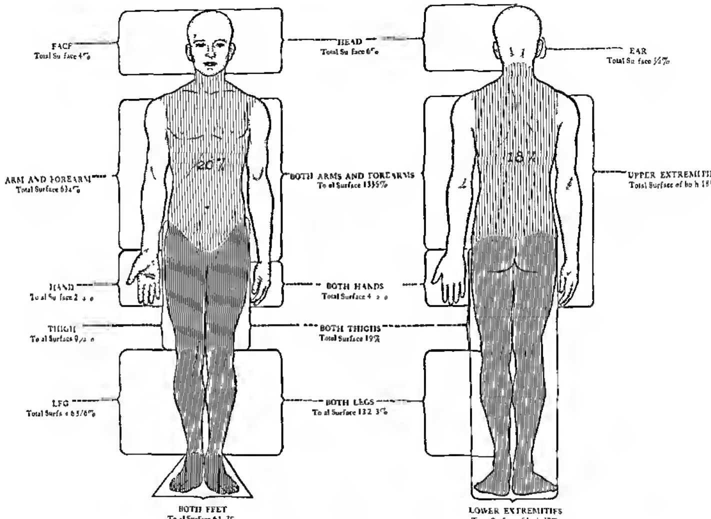


Fig 171 Berkow's chart for estimating percentage involvement of skin area in burns

FIG 172A Aseptic dressing of a burn (Note use of fracture table) Bandages having been removed by operating room aide as shown on right assistant then cuts outer dressings with sterile scissors Surgeon then removes proximal dressings as shown at left of picture The entire patient is sterilely draped as for any major surgical procedure The use of a fracture table for the dressing of burns particularly of the extremities permits of easier approach to all parts of the involved extremities and more adequate irrigation without soiling of the operating table linens and the patient outside of the area under immediate attention

hours Each unit of 250 cc of plasma is equal to 12 5 Gm of protein Since a severely burnt individual may lose up to 300 Gm of protein per 24 hours (Levenson Lund Co Tui Mullholand) it is apparent that the volume of fresh plasma needed in such cases may be prohibitive for technical or economic reasons Recourse must then be had to the use of amino acids either per orum or per venum 250 cc of a 5 per cent solution of amino acid contains an amount of protein equal to 250 cc of plasma The latter nevertheless has the advantage of more rapid assimilability and can be given more rapidly Hence where protein is needed quickly or desperately plasma is the choice For methods of calculating amount of plasma needed see Chapter 15

Mineral Balance The maintenance of adequate mineral balance is an indispensable concomitant of adequate protein levels This can be accomplished by infusion of normal saline preferably with ascorbic acid vitamin B complex and sodium bicarbonate as conditions dictate The greater the sodium needs of the patient the more plasma will be necessary The quicker this mineral need is compensated the less plasma

or even whole blood will be needed In any case, the latter should replace the administration of plasma as indicated by clinical progress and laboratory findings For, in extensive burns, there occurs sooner or later extensive destruction of red cells Plasma will not restore the oxygen carrying capacity of the blood

Biophysical Treatment of Burns

The proper biophysical care of the burn wound dictates uncompromising asepsis

Fig 172B Aseptic dressing of a burn (*Continued*) (*Top*) Wound is then lavishly irrigated with saline and cleansed as shown at right and left respectively Irrigating fluids drain directly into strategically placed receptacles under extremities. Note Mayo table under each leg This expedites individual asepsis of each extremity (*Bottom*) Entire region affected by burns is thoroughly dried with fluffed gauze

FIG 172C Aseptic dressing of a burn (*Continued*) (*Top*) Affected region is then blown dry or lightly 'peppered' by boric acid sulfanil amide, streptomycin, 1 per cent phosphoric acid, or irradiated by ultraviolet light as indicated by bacterial flora of burn (Topical application conditional) (*Bottom*) When thoroughly dry, it is covered by proximal dressings of dry gauze, white petroleum jelly, fiberglas, Xeroform scarlet red gauze (3 per cent), or pyruvic acid ointment, as dictated by surgical pathology (see text) If wounds are granulating and clean, split skin grafts are the logical dressing

surgical toilette, judicious debridement adequate splinting of the burned tissues and in extensive and separate cases, homo grafting Judicious debridement demands emphasis on conservation of all possible sources of unburned epithelium In other words never remove tissue not definitely destroyed and never probe around in tissue which is viable (see Fig 173)

Asepsis Quite as important as physio logic maintenance is the matter of aseptic management of burns A large proportion of burns are infected by medical personnel Though severe third degree burns are gen

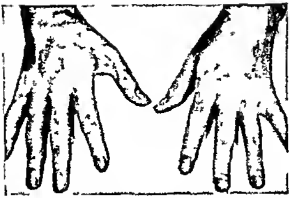
Fig 172D Aseptic dressing of a burn (*Continued*) (*Top*) Proxi mal dressings are then covered by lavish layers of gauze and cotton (*Bottom*) The ensemble is then bandaged in place to form pressure dressings as shown at right of photograph This is reinforced by elastic stockinette as shown applied to patient s left leg

FIG 172E. Aseptic dressing of a burn (*Continued*). (*Top*) Final appearance of stockinette reinforced dressing. (*Bottom*) End result (predominantly third degree burns) with necessity for only minimal free grafting Ten weeks postoperative Note surprising skin regeneration

erally admitted to be surgically the most serious open wounds, the aseptic management thereof lags far behind the respect accorded simple incisions. It is one of the surgical paradoxes of the century. A general survey of the daily management of third-degree burns would undoubtedly reveal that the practice is not too dissimilar from the days when obstetric patients were delivered with no greater ceremony than the rolling back of the doctor's shirt sleeve. As a matter of consistency with modern knowledge, all third-degree burns must be accorded the aseptic considerations practiced in the severest internal operations (Fig 172). No third-degree burn should ever be looked at by anyone without the individual's being properly masked and gowned No third-degree burn should ever be exposed without the patient's being masked, if that is at all physically possible *All third degree burns of the head, face, neck or genitals should be attended to immediately by total shaving of the scalp or the pubes respectively, whether the patient is male or female* Such burns should be kept sterilely covered at all times and never uncovered, except under operating-room conditions *The routine dressing of an extensive third-degree burn in the patient's own bed is a lamentable act inconsistent with the knowledge and the conscience of modern surgery—it is surgical treason!*

Surgical Toilette. Reasonable surgical toilette does not mean the habitual covering of burns with petrolatum gauze Where possible, it implies thorough and gentle cleaning of the involved part with bland soap lather and water and scrubbing of the entire patient where permissible; shaving of the adjacent areas; painting these areas with ½ to 1 per cent tincture of iodine and never applying anything to the burnt part which in any way would tend to irritate it (Plate 3 and Fig. 173). This is usually accomplished by gentle handling and protection of the burn until demarcation indicates the amount and the depth of tissue which

PLATE 6



Healed deep second degree burn of hands in a Negro Note the conservation of skin details and function also loss of pigment and its eventual return in the burnt areas Proximal dressing in this case was scarlet red (Biebrick s) 3 per cent in lanolin and white pet rolatum

has to be sacrificed (unless immediate excision of a burn is possible) This is not a simple matter It calls for experience and mature judgment At times it is amazing how an originally hopeless appearing burnt area with proper surgical toilette and kind ness will sprout with islands of epithelium, sometimes after four or five weeks, which ultimately reduce the tissue cost through grafting to a most gratifying degree (Fig 173) This does not mean that one should temporize with the grafting of extensively burnt patients, for there are in such cases more important considerations than tissue cost alone But it does mean to reemphasize the fact that where skin is at a premium, no effort should be spared to conserve what islands of skin epithelium may lie buried as potential seeds of new skin which, under favorable conditions, may rapidly reduce a burnt area to a surprising degree

Debridement and Topical Applications *Probably the oldest method of ex* pediting the sloughing of burnt tissue is the water bath It is usually credited to Hebra and is a procedure still employed in practically all Vienna hospitals Blair and Brown recommend tub soaks in hypertonic saline in certain cases

In the ordinary tub bath, a 2 per cent sodium chloride (commercial salt) solution is used The patient may be kept in the tub for from 2 to 8 hours each day, taking food while in the tub He may be placed into the tub, dressings and all, where these are present Between baths, the conventional petrolatum gauze and pressure dressings are applied

The time element involved in the demarcation of burnt tissue is often physiologically taxing to the patient and physically trying to the surgeon The expediting of this phase has been a long sought for advantage This has led Connor and Harvey to the use of 0 1 molar pyruvic acid in starch paste,* in expediting the separation of the slough from about 20 days to approximately 8 days In spite of promising clinical results, the method had certain

Fig 173 Originally third degree burn (clinically) showing rapid centripetal growth of new epithelium and sprouting of epithelial islands (practically equivalent to "pinch grafting"), a sign and the result of considered topical management of burned area

* **Connor, G J and Harvey, S C** The pyruvic acid method in deep clinical burns Ann Surg **124** 799 810 1946

A 0 1 molar solution of pyruvic acid is prepared **by adding 6 8 cc** pyruvic acid (Eastman No 498) **to one liter of** distilled water (resulting pH is 1 9), **80 Gm of ordinary** cornstarch is suspended in a few **ounces of the cold** pyruvic acid solution The rest of **the liter of 0 1 molar** pyruvic acid is heated to the **boiling point,** and the cold starch suspension is added **slowly, with** stirring Heating is continued for a few **more minutes,** and the resulting pyruvic acid starch **paste is allowed** to cool The pH of the finished gel **is 1 8 to 1 9**

drawbacks The starch paste is difficult to prepare it is unstable and does not lend itself to easy general application The pyruvic acid itself is unstable and very difficult to procure in adequate amounts for general clinical use

Hence Sulzberger Kanof and Baer after a classical experiment on 1 500 human volunteer subjects have shown that the capac ty for debriding burnt tissue or for that matter any dead tissue is not peculiar to pyruvic acid Their conclusion is

> Thus our results completely confirm the findings of Harvey and Connor that not only the original hydrogen ion concentration but the buffer capacity of the acid is important in the achievement of slough removal The more weakly dissociated ac ds have a larger reserve of hydrogen ions and are able to maintain the low pH for a longer period of time However at the same molarity there appeared to be differences in the efficacy of different acids Phosphoric acid 0 1 M at a pH of 1 9 was as good as pyruvic acid 0 1 M at a pH of 1 9 tartaric acid 0 1 M at a pH of 2 0 and mandelic acid 0 1 M at a pH of 2 2 were not as good as pyruvic acid at a pH of 1 9 Citric acid 0 1 M at a pH of 2 0 was inferior while lact c acid 0 1 M at a pH of 2 3 was almost ineffective *

Chemical methods of removing burn sloughs have three things in common they shorten the period of separation by 50 per cent or more they reduce the incidence of infection materially and they obviate some of the structural complications associated with the conventional procedure of time tempest and tolerance The chemical debridement of burnt tissue promises to be a valuable addition to the armamentarium of the surgeon

Notwithstanding O Cope J L Langohr F D Moore and R C Webster recommend a more radical step in the solution of the vexing problem of disposing of the burnt tissue They take the ultimate manual step possible to the surgeon that is immediate excision of the third degree burn with on the spot free grafting of the surgical wound Their enthusiasm for immediate surgical excision general care of the patient allowed is evinced as follows

> It is an extraordinary commentary on the passivity of the surgeon that he has been sitting on the sidelines for so many years watching the full thickness burn wound degenerate into a bacterial quagmire when the means of healing it promptly by excision and grafting a simple practice of his art were at hand Are there any extenuating circumstances for his passivity? We cannot accept a fear of unseating homeostasis by an operation or the lack of chemotherapy as excuses In patients with burns of limited extent there is no danger of producing shock and yet early grafting was not tried †

Theoretically this would seem to be the choice procedure Clinically it can only be the procedure of choice in certain cases But eventually only time and a controlled mass of experience in the operating room can impose the practical over all reasonableness and application of such therapeutics

There is little question that burns involving less than 5 per cent of the body surface can be and have been treated according to this plan particularly electrical burns But from a physiologic standpoint a patient with a third degree burn of 15 or more per cent might be permanently jeopardized through the combined effect of accident and surgical trauma to a formidable degree This is pre eminently true in young children The method must be used with caution always remembering that the basic consideration is the treatment of an extensive burn in the treatment of the patient

As to the application of immediate excision or amputation in electrical burns at least experience in the hands of those conversant with the peculiarities of such burns would seem to contradict Cope et al It has been shown by Stephan Jellinek Professor

* Sulzberger M B Kanof A and Baer R L Stud es on the acid debridement of burns Ann Su g 125 April 1947

† Cope O Langohr J L Moore F D and Webster R C Exped t ous care of full th ckness burn wounds by surg cal excision and graft ng Ann Surg 125 Jan 1947

PLATE 7

Extensive third degree burns of the lower extremities treated with mixed chlorophyll and penicillin (9 days after application), because infected by *B Pyocyaneus*, *B Staphylococcus* and *B Streptococcus* Note the condition and quality of the granulation tissue as well as incipient epithelial proliferation remaining around the chlorophyll

of Electropathology University of Vienna that early surgery in electrical injuries including burns is not only extraordinarily shocking to the patient but that the resultant surgical scars cannot compare qualitatively with those remaining after biologic amputation The incidence of postoperative infections is vastly higher even with scrupulous asepsis than when the burnt part is simply washed with benzene and alcohol and aseptically *dry* dressed In my experience with electrical burns Jellinek s thesis has stood the test

It is nonetheless proof of the relative paucity of the contemporary treatment of burns and at one and the same time inspiring evidence of the potential capacity of modern surgery when once all available forces are marshaled and directed toward the solution of a critical problem

Eschar treatment has had its day It is a quite logical but unreasonable treatment because it is distinctly unphysiologic It depends on the physicochemical control of dead tissue rather than the biophysical reparative properties of live tissue Although in selected cases it may seem to make management and nursing easier it prolongs treatment adds nothing to (and more often subtracts from) the natural reparative processes responsible for good esthetic as well as functional results

Splinting and Pressure Dressings Adequate splinting means not only physical but physiologic splinting of soft tissues to reduce plasma loss edema pain bleeding endocrine exhaustion and secondary shock This is usually accomplished by calculated pressure dressings (Figs 74C and 172) An adequate pressure dressing is one which maintains free grafts in apposition to their recipient sites in a manner consistent with physical and physiologic security Some years ago Ferris Smith worked out the ideal pressure necessary over free grafts It is estimated to be equal to 30 mm of mercury Less pressure predisposes to hematoma or seroma formation under grafts dislocation of the graft or edema of the bed Too much pressure may lead to interference with the ingrowth of capillaries from the bed into the graft or necrosis of the graft itself

Fig 174 The physiologic invalid Appearance during convalescence Note emaciation and loss of subcutaneous fat as evidenced by prominence of temporal vessels and sunken eyes

Blair states that

> The application of most any dressing produces pressure but he who employs this pressure *in a selective purposeful manner* will get bigger returns than he who applies it incidentally or even as a matter of routine *

H Allen makes this interesting observation

> The elimination of dead space into which constant oozing can take place and the limitation of exudation from the surface of a wound and into the subcutaneous tissues are important objectives in wound treatment which are too often completely ignored The surgeon who sees blood escaping rapidly from an open wound instinctively applies pressure to stop the bleeding and conserve vital body fluid By some curious inconsistency if we cannot see

* Blair V P The influence of mechanical pressure on wound healing Illinois M J 46 249 1924

it we may ignore the subcutaneous bleeding that goes on just as definitely after the subcutaneous rupture of blood vessels and continues until it is arrested either by coagulation or by actual compression of the injured blood vessels by the tensed body tissues If the

FIG 175 The burnt chronic This type of patient is essentially a nutritional and nursing problem In such patients, a viscious physiologic circle is established which must be broken lest a psychosomatic breakdown and years of invalidism follow Third degree burns involved scalp ears, face, neck, forearms hands one buttock, and both lower extremities—hip to heel Early but extravagant autografting of this type of patient may deplete skin function and general physiologic integrity to point of protracted invalidism Here, use of homografts was a major factor in eventual recovery

subcutaneous bleeding is the 'white hemorrhage' that goes on in tissues injured by a flame or scalding water, it needs to be arrested just as promptly as if the blood were escaping from a torn blood vessel It can be arrested and body fluid saved by the application of pressure over the injured area *

Neal Owens concludes

It has been our experience that by the use of pressure dressings in the treatment of burns and infected wounds the incidence of complications due to infection has been lowered the duration of hospitalization shortened, and the complications reduced A properly applied pressure dressing offers comfort to the patient during the first 18 to 21 days because of evenly distributed pressure and its splinting effect This is in favorable contrast to those patients in that group who presented initially only contaminated wounds, who formerly were subjected to the terrific pain associated with the frequent change of dressings during this period †

* Allen H S and Koch S L The treatment of patients with severe burns, Surg., Gynec. & Obst 74 914 1942

† Owens Neal Use of pressure dressings in the treatment of burns and other wounds Surg Clinics of N A., Oct., 1943

Obviously there is rather general agreement on the question of pressure dressings in burns For guidance to the student it must be emphasized that a pressure dressing is a calculated form of near physiologic splinting of badly wounded soft tissues Like all technical procedures it needs precise and knowing application It is therefore imperative for the student of surgery to have exact knowledge of the significance of pressure dressing Apropos Ferris Smith s research the simplest way to become conversant with the meaning of the term is to apply a Baumanometer sleeve to one s arm or leg and induce a pressure of 30 mm of Hg in the cuff By feeling inspecting and palpating the Baumanometer cuff at that pressure one soon retains practical knowledge of the tension and the feel of it translatable to the consistency of the conventional pressure dressing

This is not to imply that all pressure dressings must at all times be exactly equal to 30 mm of Hg The site of application the nature of the tissue the elasticity and the composition of the dressing its volume and other variables influence the proposition But the above is a safe general guide and basis for judgment as to the adequacy of wound covering

Homografting (A biologic dressing) In extensively burned patients who have been treated by the conventional methods of debridement after demarcation adequate biophysical care involves the use of homografts This is a life saving procedure and biologic expedient which has as yet no physical or chemical substitute Its more extended use should be encouraged (Fig 106 and Plate 4)

This phase of the subject was eminently demonstrated during World War II in some of the Plastic Centers established by the Office of the Surgeon General Personally I have had experience with a number of cases in extremis where all that was reasonable and known had been done for such cases without success Only with the massive application of homografts and hence the conservation of what little remained of the patient s biophysiology (by turning a physiologic sieve into a relatively closed vessel) was it possible to save the patient s life The obviously failing severely burned

Fig 176 Breakdown and ulceration in a chronic burn of the right leg Note sclerosed skin and practically absent circulation Treatment necessitates complete excision of sclerosed tissues and full thickness grafting via flaps or tubes In this case a long thoraco abdominal tube is preferable to maiming of contralateral extremity by the mobilization of the amount of tissue needed to cover entire leg

FIG 177 Extensive ulcerations in chronic burn Note emaciation of patient Physiologic depletion of patient makes thorough and comprehensive general treatment imperative Excision of ulcerations to good base and free grafting is necessary as soon as general condition is under control If extent of ulcerations is such that general treatment is being compromised by open wounds themselves early biologic dressing of wounds via epidermic grafts should be done

patient who responds poorly or not at all to established forms of treatment is the superior indication for homograft therapeusis Any normal type of skin may be employed

It is as yet an entirely empiric form of treatment There is no biologic knowledge to account for the frequent temporary 'take' of homografts and their eventual and invariable failure Most homografts will undergo lysis and discard by the body in from nine days to five weeks They then have to be replaced by autografts, if possible Patients who are so badly burnt as to need homografting usually have little skin of their own left from which to draw on later, except to graft functionally imperative areas such as the joints, the face and the genitals The longest surviving homograft in my hands has stayed 184 days For further considerations of homografts, see Chapter 16, 'Skin Grafts and Grafting"

THE OPERATIVE CURE OF BURN WOUND

The operative cure of a burn resides in early and judicious autografting, consistent with the extent and location of the burn, and the amount and integrity of normal skin available on the patient The practice of overambitious skin grafting, which only adds surgical insult to traumatic injury by depletion of the remaining normal skin, is to be discouraged The skin is an organ, physiologically as pertinent as the liver, the kidney or the gastro intestinal tract Just so much of any of these, skin included, can be spared, after which physiologic, if not physical, invalidism results (Fig 174)

The logic of early skin grafting in the case of extensively burned patients can be pushed to the point of physiologic unreasonableness In a patient with 50 per cent of his body burned, it is theoretically possible to skin graft the entire wound by mobilization of skin from the remaining unburned 50 per cent of the patient, or repeated mobilization from a lesser area The answer to the unreasonableness of such a procedure, from a purely physical standpoint, lies in the question What of the patient who is suffering with a 60 per cent burn? The solution to the problem of early but sane grafting of extensive burns lies in a physiologic as well as anatomic perspective of the injury In other words, where a burn is so extensive that physiologic invalidism may be the price of adequate grafting, only such portions of the injured part or body should be autografted as are absolutely necessary to the basic function

of that part The remainder if necessary and for the time being may be homografted This may imply a disregard for certain esthetic factors in the repair but of what use is a pair of well grafted good looking arms if the wrist joints do not work? Especially if one has made a physiologic invalid of the patient such surgical management of burns is unreasonable Beyond certain limits skin grafting becomes a destructive operation

The Physiologic Invalid A physiologic invalid created by the extravagant mobilization of unburned skin and its rampant application is one who after the cure of a burn and complete ambulation begins to complain of hot flashes frequent urination vague abdominal pains headaches malaise palpitation salty taste difficulty in adjustment to sudden temperature changes conjunctival irritation and tiring too easily The clinical picture is not one to be entirely explained as a possible consequence of the burn per se

The argument may be advanced that if the mobilized grafts are very thin there is no fear of permanent physiologic injury Unfortunately such grafts are too often functionally inadequate particularly about joints weight bearing surfaces and the ever mobile face Consequently it is necessary to use thick split or even full thickness skin grafts at times In the case of the face there is no other choice This too frequently leaves the donor site unable to grant any more skin The problem of skin supply in extensive burns remains a problem The problem of the over all treatment of extensive burns is far from the final solution It is a pertinent stimulus to further research

Grafting Procedures Where a third degree burn involves less than 5 per cent of

Fig 178 Burn ulceration of 9 years duration Note piling up of ulcer edges and atrophy of leg with edema of foot Also observe small deep circumscribed ulceration within upper horn of granulating area Such a clinical picture is suggestive of possible beginning malignant metaplasia of burn Biopsy of ulcer proved this to be true here

FIG 179 (*Top*) Marjolin ulcer in burn of 30 years duration Note friable necrotic un dermining ulcer edges and glossy pale and edematous ulcer bed with spotty heaped up tissue Patient refused surgery (*Bottom*) Same case five months later Definite malig nant hyperplasia has set in Microscopically diagnosed as carcinoma Amputation of leg was done (Line about instep is a rubber band supporting case number on opposite side)

the body the destroyed tissue may be ex cised immediately and the surgical defect grafted In exercising this privilege one must be thoroughly conversant with recog nizing the lines of cleavage between burnt and unburnt tissue The signs vary in burns of diverse origins such as electrical X ray chemical heat and steam burns They also vary in the cleavage between different tissues

Where a burn involves 20 per cent or more of the body, the patient is usually in too precarious a general condition to withstand the additional surgical trauma of immediate excision and grafting From the standpoint of physiology it must be borne in mind that the excision of the burn is only half the surgical insult from which the pa

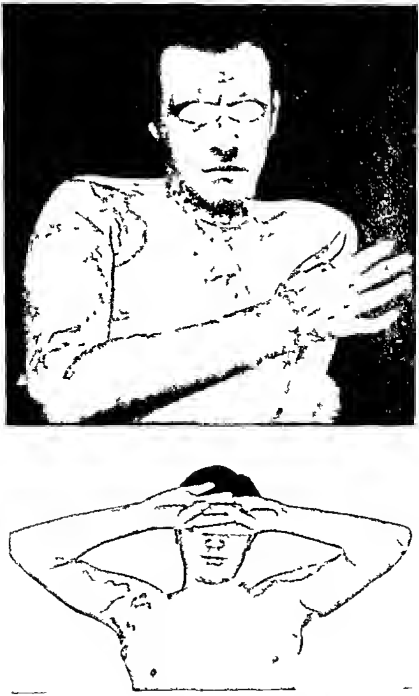


FIG 180A Burn consequences Scars (*Top*) Hypertrophic (*Bottom*) Keloidal

tient suffers if grafting is to follow immediately The mobilization of skin grafts is the other half of the insult So that in excising a 10 per cent burn followed by immediate grafting the patient s body economy is taxed by a 20 per cent wound of the organism s skin—not to mention the already existing consequence of the burn per se

Coincidentally the mob lization of more than four Padgett drums of skin or about 120 sq in is a rather telling procedure I have removed as high as seven drums or 210 sq in of skin (0 018 in) from one patient at one time without any serious consequences but the patient nevertheless knew he had been operated upon Only in exceptional cases should more than about 120 sq in be taken at one time The split graft ranging from 0 010 to 0 020 in is generally the thickness mobilized and has proved to be adequate except on the face and the weight bearing areas

Where a patient has suffered say a 40 per cent (or more) burn it is far better to autograft only the face and the joint areas and homograft the remainder of the burnt body As the homografts slough time and new skin regenerating in the original donor sites make the management of such cases far safer and easier

Fig 180B Burn consequences (*Continued*) (*Left*) Defacement preoperative Note minimal interference with function due to superficial nature of scarrings (*Right*) Same case two months postoperative Affected skin was excised and free grafted with full thickness skin grafts Note rehab litation with adequate closure of eye l ds

LATE SURGERY

The late surgery of burns has to do with neglected or maltreated cases and has for its immediate problem the physiologic repletion of the individual eradication of chronic infection ablation of ulceration and early ambulation of the patient to obviate invalidism This is accomplished by certain physical and operative interim procedures such as adequate functional splinting baths exercise massage early use of the affected parts and chemotherapy It in

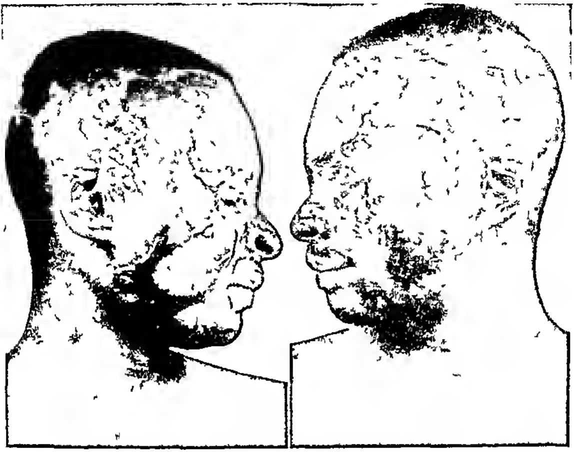


FIG 180C Burn consequences (*Continued*) Facial distortion due to burn Face has been partially 'patch grafted by skin too thin to subserve facial functions Such grafts have to be replaced by full thickness skin or pedicle flaps from pectoral region or from medial surface of upper arm

cludes the restoration of blood values, protein balance, vitamin levels, immunity factors, excretory efficiency and interim grafting

PHYSIOLOGIC REPLETION OF PATIENT

The patient chronically ill from a neglected or maltreated burn is one whose poor physiologic integrity makes him a questionable surgical risk, a biologic challenge and a psychological problem (Fig 175)

Besides the obvious external findings of ulceration, infection, loss of weight and invalidism, he suffers with anemia, hypoproteinemia, dehydration, avitaminosis and frequently hepatic and renal complications Hence before any definitive local therapy can be instituted, the individual as a whole must be adequately treated All necessary laboratory investigations should precede any local treatment except cleanliness as guideposts to adequate general management Repeated blood transfusions are usually necessary These should be continued until the hemoglobin remains above 80 per cent for at least nine days

The chronically ill patient is essentially a nutritional problem Hence large amounts of protein are necessary, with considerable carbohydrate If the patient is unable to

FIG 180D Burn consequences (*Continued*) (*Left*) Eyelid deformities due to third degree burn All scars must be excised, tissues replaced, tarsorrhaphy performed and lids free grafted (*Right*) Tissue voids due to tar burn Both eyes, ears, eyebrows and nose, with major portion of scalp and all of facial skin, are lost Forehead skin, alloyed with tar, is still present (For reconstruction of case, see Chap 22, "The Full Face Graft" See also Plate 8)

take sufficient nourishment per orum protein in the form of amino acids must be administered parenterally This may have to be continued for several weeks Amino-acids are usually given in 5 per cent solutions and in these cases 500 cc or more at one time up to 3 000 cc per day The latter is equivalent to 150 Gm of protein Water and vitamins usually can be supplied in adequate amount by mouth Heliotherapy by direct sunlight or quartz lamp is not to be omitted

Chemotherapy of Infections

The infections most commonly to be controlled are those due to (1) *B Proteus* and *B Coli*, which are eradicated by poultices of or drv dusting with boric acid and administration of streptomycin, (2) *B Pyocyaneus*, which is controlled by the topical use of sulfacetamide, Cellosolve solvents, 0 5 per cent phosphoric acid solution, or chlorophyll (Plate 7), (3) the symbiotic infections of staphylococcus, diphtheroids and various diplococci, which are controlled by the topical applications of peroxides, saline compresses and internal administration of penicillin To break a vicious pathologic cycle, frequent infusions of whole blood are the most necessary complements to any chemotherapy

Burn Ulcerations

The ulcerations so commonly found in this type of case, which are the result of a vicious local tissue condition, are the next consideration These are usually dermal in character and the result of fibrosis and tissue tension, they are best treated by excision and early split grafting (Fig 177) Or they are the indolent type of ulcer due to poor blood supply resulting from

gradual fibrous constriction of an area about the wound as well as poor innervation due to tissue distortion These are best controlled by incision or partial excision of the

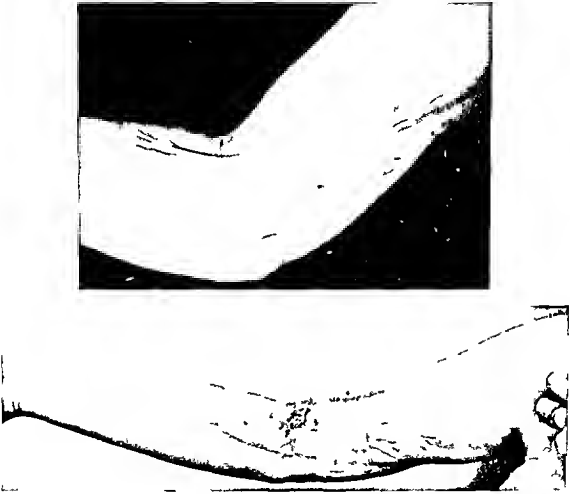


Fig 181 (*Top*) Burn contracture of elbow (*Bottom*) Resolution of elbow contracture via modified Z plasty on scar tissue which had been previously softened by physiotherapy Note spot necrosis in center of medial flap This is a common occurrence when working with scarred tissue Such areas when they appear may be excised and free grafted immediately Notwithstanding the entire procedure is accomplished at a much lower tissue cost than if all the scar had been excised originally In that case a large abdominal or chest flap would have been necessary, a tissue cost prohibitive in this woman Functional result was good

scar tissue and free grafting of the resultant surgical defect (Fig 178)

A group of ulcers not infrequently missed in diagnosis and probably a greater problem in management than even those mentioned above are the so called Marjolin ulcers the epidermoid carcinoma and the sarcomas (Fig 179) These are due to years of neglected and persistently aggravated unhealed burns When excised early and grafted they never return If the malignant transition is permitted to the point of involving fascial or bony structures amputation or death is the unavoidable consequence Every burn ulceration of long standing should be routinely biopsied

Ambulation Therapy

The next important consideration in the management of old neglected burns is the early ambulation of the chronic, anemic and depleted patient to avoid renal, joint, liver and pulmonary complications and to prevent extensive bone and muscle atrophy This necessitates, among other things, the treatment and the protection of scars of all types such as keloids, the hypertrophic scar and others, against injury and infection Where injury to a tense scar or keloid is unavoidable because of its position and ordinary use of the part, the part must be splinted out of action or the scar must be relaxed by early incision and free grafting of the surgical defect before the patient is allowed to use the part Such interim treatment must be continued until the patient's general condition and the condition of the scar permit adequate reconstructive surgery under as ideal conditions as possible (See Chap 18 Surgery of Scars)

RECONSTRUCTIVE SURGERY

The reconstructive phase of the surgery of burns has for its purpose the restoration of form function and appearance This may be accomplished in one of three ways, namely (1) surgical management of scar tissue per se, (2) tissue revisions, or (3) by grafting

The problems which fall under the headings of reconstructive surgery of burns are threefold (1) scars (2) tissue derangements and (3) tissue voids Tissue derangements are of three types defacements, distortions and deformities Tissue voids are of two types partial and total loss (Fig 180 See Chap 9, Diagnosis')

The Surgical Management of Scar Tissue

The operative treatment of scar tissue per se is often an inescapable procedure in order to avoid excessive tissue cost in a reconstruction and to expedite rehabilitation Where a burn is very extensive and tissue is at a premium, it may be the only reasonable thing to do, at least for the time being Where a scar is obviously undergoing sclerosis due to constant tugging or tension, direct attack upon it may be the procedure of choice, because any surgery upon the scar itself which will relax it will often result in sufficient improvement of its quality so that it can later be used in the actual reconstruction of the affected part (Fig 181)

A predominant percentage of the reconstructive surgery of burn consequences is the surgery of scar tissue It must be constantly borne in mind not to operate too early on a scar that is the result of a burn The price of such daring is more scarring or keloid formation One must discipline oneself never to operate definitively on scar tissue until all signs of activity have disappeared and the scar is dry, pale and organized—with such exceptions as have been mentioned heretofore For definitive procedures, see Chapter 18, 'Surgery of Scars '

Surgery of Tissue Derangement

Tissue derangement following burns is particularly prone to occur on the face, the hands, about the genitals, the orifices and the female breast These, as indicated heretofore, are of three types defacements, distortions and deformities

Defacements are superficial scars involving as a rule no more than part of the full thickness of the skin, usually due to flash burns, and the clinical problem is essentially one of improvement of appearance (Fig 180C) If they occur on unexposed parts of the body they can be disregarded If, on the other hand, they do occur on exposed parts, the treatment is usually one of partial repeated excision with ultimate approximation of normal edges, immediate complete excisions with grafting, or tattooing to a degree matching the surrounding skin The last is strongly recommended by Blair and Brown Whether or not it will prove to be a good physiologic procedure is something for the future to reveal, for

PLATE 8

(*Left*) Panfacial burn (fourth degree) due to tar Note absence of ears, right eye (right eyeball, though still present, is beyond hope of saving), eyebrows, nose and parts of the upper lip Also observe involvement of scalp the frontal area of which is totally replaced by tar scab The patient was conscious and hopeful Entire face was covered by split grafts (0 024 in) at one sitting, taken from chest and abdomen Both hands, forearms and lower extremities were involved by third degree burns of same origin (*Right*) Postoperative condition of patient with panfacial burn (23 days) Note complete "take" and organization of grafts with good formative results Patient is totally blind after tar burn, yet cheerful

FIG 182 Ablation of facial patch graft by partial excision and dermoplasty (*Left*) Thick split graft replacing excised burn scar Note color contrast with normal skin of face (*Two center pictures*) Reduction of patch graft by partial excision (*Right*) Final extirpation of free graft and revision of defect by rotating paranasal flap of normal skin to cheek

tattooing means the injection of foreign material Tattooed areas have been known to become malignant It is nonetheless a comparatively quick and easy form of ablation of defacement by subtle disguise

The free graft too has certain obvious drawbacks because it is in itself a pseudo physiologic tissue and therefore not always consistent with esthetic expectations As a result it too frequently has to undergo partial repeated gradual excision with eventual approximation of normal skin edges or exclusion by some type of dermoplasty (Fig 182)

Distortions, in contrast with defacements, present the problem of form as well as appearance, due to deep involvement of all the soft tissues pertinent to the shape of the part Unless form is recovered, function may be out of the question This is particularly so with burns of the genital organs, hands, orifices, lips, ears, eyelids and nose The restoration of both form and function can be accomplished only by complete and symmetric replacement of all lost tissue For this purpose one can resort to the full thickness free graft the inshifting of collateral tissue the use of the several peduncled flaps the tubed tissue or a combination of these The choice of any one of these depends entirely upon the experience of the surgeon, the size and the extent of the defect, the type and the location of the deformity, the tissues available and their suitability if brought in from a distance

The best type of plastic reconstruction, all things considered, is one which can be carried out with the tissues in the immediate vicinity of the defect (Fig 182) If this is impossible, tissue has to be imported to the defect from other parts of the body Ultimately the most important consideration is that an accurate diagnosis of the lesion or the defect be made so that in

FIG 183 (*Left*) Result of poor selection of grafts in reconstruction of left hand Dorsum was covered by epidermic grafts too thin to withstand function and hence broke down with secondary scarring as shown A pedicle flap was applied to the thumb and the index fingers This as seen is too clumsy in appearance and needs secondary fatty excisions It is also functionally inadequate because it fails in straddling first web thus making full abduction of thumb difficult A large thick split graft for the entire hand would have been satisfactory (*Right*) Results of poor judgment in grafting of extensive tissue loss of leg Several attempts apparently had been made to cover area in none of which were adequate amounts of tissue prepared to answer the need hence, the patchy appearance of the result For this type of lesion a large abdominal or thoraco abdominal tube and if need be a supplementary flap or tube from contralateral thigh is indicated

the reconstruction such tissues are brought in as are the ilk of those lost If this is not done the repair will be cosmetically inadequate or will not stand the stress and strain of time and function (Fig 183)

Unquestionably, the most outstanding and grotesque distortion is the pan facial burn (Fig 184) The adequate solution to this problem is still a thing of the future There is no question but that complete restoration of the face must be done Tissue must be imported, but how, in what form and with what timing still awaits final solution

The conventional procedure is to take one small part after another and reconstruct it by one or several of the methods indicated There are serious objections of time, expense and esthetic result to such a procedure It may take five years It always results in a patched face of multicolored grafts, not one of which may match another The face remains grotesque

The quickest and least expensive method, both as to tissue cost, time and pain *and the most promising from the standpoint of color* homogeneity and appearance is the *full face*, full thickness free graft This implies total free grafting of the entire face in one surgical inning It is a rather trying experience, for both patient and doctor although it consists of only one operation lasting from 7 to 9 hours The medical literature offers little help in full face restorations They remain extraordinary cases set apart because it is one of the larger problems in plastic surgery, embodying technical considerations, both difficult and innumerable (See Chap 22, 'The Full Face Graft")

Deformities may occur anywhere on the body and are the result of the involvement of tissues pertinent to the complete form and function of a part This implies the severest of burns, without actual loss of the part From the standpoint of reconstruction, it also implies the total loss of function or near total loss of function and subtotal loss of form This is so because in this type of injury there is nothing of surgical consequence left in situ with which to plan the repair, except some deep or skeletal tissues, the rest has all gone to scar or been replaced by it These are the 'frozen' cases Here often the question of amputation and replacement by prosthesis or, where possible, complete reconstruction of the part becomes a matter for judgment and decision

This type of injury is particularly common to the ear, arm, hand, eye, nose and the lips (Fig 185) In these cases too often

Fig 184 The panfacial burn Note total destruction and scarring of all *covering tissues of face and head* (See Chap 22, The Full Face Graft')

the best the surgeon can do is never good enough On the other hand this type of case is evidence of the fact that plastic surgery has only scratched the surface Nevertheless, with unusual surgical patience, inordinate courage on the part of the patient time, imagination and the most exacting surgery, quite commendable results can be obtained

These cases usually demand the services and the experience of many specialists, and that is as it should be Every conceivable means in surgery from physical therapy to neurosurgery, and sometimes psychiatry, must be brought to bear on the case in order to succeed When acceptable results are obtained, it is worth the price and the effort because the best prosthesis or physical substitute never can be as good as a fair surgical result, for the simple reason that where there is no life there is no feeling Without

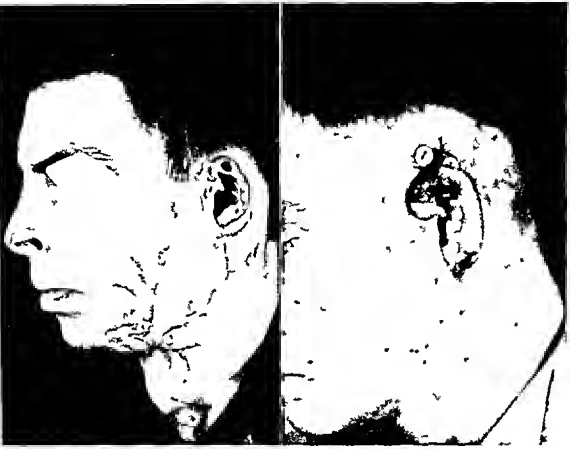


FIG 185 Typical burn deformity of the ear (*Left*) All soft tissues of ear have been lost and only the shriveled scar covered cartilage remains Reconstruction begins by the importation of soft tissues (*right*) In extensive burns of the ear the collateral tissues are usually affected to such a degree (as shown in photograph) that none is available for the repair Note irradiation of scars of face by repeated partial scar excisions and advancing of cervical skin before otoplasty is begun This is good practice and a basic requirement to establish normal tissue relationships and good blood supply for the ear reconstruction

feeling there can be little ultimate satisfaction (For specific reconstructions of individual parts or appendages see appropriate chapters in Section III)

THE SURGERY OF TISSUE VOIDS

These are cases or conditions of actual burn amputation of a tissue or a part Although not uncommon in thermal burns they are the rule in severe electrical burns The ultimate problem in these cases of course is one of form function and appearance In a manner of speaking these cases are not as difficult as tissue deformities per se This is so because where a patient has suffered a total loss of a part anything representative of it which is possible for surgery to produce is better than nothing and nothing is what the patient started out with With the limited knowledge we today possess of reconstructive surgery only limited burn amputations such as the loss of nose ear mouth jaw and penis stand any hope of surgical mimicry Obviously burn amputations can involve any part of the body The fundamental phases in the reconstruction of lost parts are the restitution of the soft tissues the supplying

Chart 6 Outline of Burn Management

RECEIVING ROOM

1 Wear gloves and mask
2 Never pull dressings from grafts
3 Soak proximal dressings with saline or H_2O_2 (have patience)
4 Grasp each and every suture with hemost, steady, and only then lift dressing from graft
5 Clean graft area with H_2O_2 and dry
6 Replace modified pressure dressings
7 Start passive motion (*use judgment*)
8 Do not redress for minim of 100 hrs

BURN "CACHEXIA"—DURATION 10-30 DAYS

1 Forced feeding (3,500 cal—protein 200 Gm or or more)
2 Whole blood (500 cc or more daily)
3 *5% sol amino acids—1 000-1,500 cc per diem* with—
4 Vit B complex (5 amps) and ascorbic acid particularly
5 Careful about urine output (1,200 cc/diem or more)
6 *Salt intake depends on vomiting and kidneys*
7 Beware of decubital ulcers
8 If delirium appears—case is critical!

AFTER 400 HRS

Must avoid muscle atrophy and joint ankyloses
Institute at least passive motion after first postoperative dressing of graft

LATE PO CARE

1 Use protective dressing for 2 4 weeks after ambulation
2 Active motion—cocoa butter massage before bedtime
3 Maintain clean graft with white soap and H_2O
4 If any grafts have sloughed prep for regraft

OPERATING ROOM

1 Expose sloughed areas sterily
2 Excise gran areas with *surrounding fibrous ring to oozing* bed
3 Control all bleeding
4 Regraft with thin split or epiderm grafts only
5 P O management same as with original graft

* Chapter 16 pp 271 273

† A 0 1 molar solution of pyruvic acid is prepared by adding 8 8 cc. pyruvic acid (Eastman No 498) to one liter of distilled water (resulting pH is 1 9) 80 Gm of ordinary cornstarch is suspended in a few ounces of the cold pyruvic-acid solution The rest of the liter of 0 1 molar pyruvic acid is heated to the boiling point and the cold starch suspension is added slowly with stirring Heating is continued for a few more minutes and the resulting pyruvic acid-starch paste is allowed to cool The pH of the finished gel is 1 8 to 1 9

‡ Phosphoric acid 20 Gm; Methyl cellulose 300; Sorbitol 60; Mix 1 part of the powder with 10 parts of water; pH of gel is 20 0 — After Sulzberger, Kanof and Baer

of a lining where a part embodies a cavity and ultimately the replacement of the skeletal structures in order to re constitute original form and function

It is a field necessitating considerable architectural ability and artistic flair as well as a gift for symmetry, which is given to some and impossible to teach to others It is a field which nevertheless is one of the most important phases of future surgery awaiting certain developments in the basic sciences and much more experience in the operating room Examples of tissue voids due to burns and their reconstruction *will be found in Section III*

BIBLIOGRAPHY

Abbott W E and Hirshfeld J W Present concepts concerning the care of the burned patient Am J Surg 74 296 301 1947

Aldrich R H Treatment of burns Acriviolet and brilliant green successfully used New England J Med 217 911 193

Alexander R J Two case reports Plast & Reconstruct Surg 3 60 65 1948

Allen H S Local Treatment of the Whole Thickness Burn Surface (Surgical Clinics of North America Chicago Number) Philadelphia Saunders 1948 pp 125 133

Allen J G Owens F M Evans B H and Dragstedt L R Sulfathiazole ointment in the treatment of burns Arch Surg 44 819 1942

Altemeier W A and Carter B N *Infected* burns with hemorrhage Ann Surg 115 1118 1124 1942

Anderson G K. The importance of protein in diet therapy J Am Dietet A 21 436 1945

Barber C G Skin transplantation by injection Its effect on healing of granulating wounds Arch Surg 43 21 1941

Berman J J et al The treatment of burn shock with continuous hypodermoclysis of physiological saline solution into the burned area Surg Gynec & Obst 78 337 1944

Blalock A Experimental shock VII The importance of the local loss of fluid in the production of the low blood pressure after burns Arch. Surg 22 610 1931

Bowers W F Chlorophyll in wound healing and suppurative disease Am J Surg 73 37 1947

Boyce F F The hepatic (hepatorenal) factor in burns Arch Surg 44 99 1942

Braithwaite F and Beales P H Some observations of Curling s ulcer Brit J Plast Surg I 284 1949

Braithwaite F and Moore F T Some observations on anemia in patients with burns Brit J Plast Surg 1 81 1948

Brown A Morphological changes in the red cells *in relation to severe burns* J *Path* & Bact 58 36 1946

Brown J B Thick split skin grafts in the repair of burns Surg Gynec & Obst 73 265 1941

Brown J B and Blair V P The repair of defects resulting from full thickness loss of skin from burns Surg Gynec & Obst 60 379 1935

Brown J B and McDowell F Plastic repair of burns with free skin grafts Clin cs *I 26 36 1942*

——— Epithelial healing and the transplantation of skin Ann Surg 115 1166 1181 1942

Brown W A et al Local application of aluminum foil and other substances in burn therapy Am J Surgery 76 No 5 1948

Browne H R Marjolin s Ulcer Report of a Case Read before the Soc of Plastic & Reconstructive Surg at Chicago Oct 1940

Brush B E Lam C R and Ponka J L Wound healing studies on several substances recommended for the treatment of burns Surgery 21 662 1947

Bunyan J Hudson R V Pearson R S B Lewis E E Niven R B and Hannay J W The treatment of burns and wounds by the *envelope* method Modern Med 2 1 7 1941

Cady J B and Morgan W S Treatment of chronic ulcers with chlorophyll Review of a series of fifty cases Am J Surg 75 562 569 1948

Cannon B Rehabilitation following severe burns Surgery 15 178 185 1944

Champion A H and McDowall A Clinical observations on the use of dibromopropamidine (M & B 12 0) for surface infections with *particular reference* to B *Proteus* vulgaris and PS pyocyanea Brit J Plast Surg 11 57 1949

Chase C H A new eschar technique for local treatment of burns Surg Gynec & Obst 85 308 314 1947

Coakley W A et al The management of severe burns Plast & Reconstruct Surg 3 667 1948

Cogswell H D and Shirley C The treatment of burns, Am J Surg (N S.) 45 539 545 1939

Connor G J and Harvey S C The pyruvic acid method in deep clinical burns Ann Surg 124 99 310 1946

Cope, O Anemia in burns, Surg, Gynec & Obst 84 999-1002, 1947

Cope, O, Langohr, J L, Moore, F D, and Webster, R C Expeditious care of full thickness burn wounds by surgical excision and grafting, Ann Surg 125 1-22, 1947

Cordier, G, et Demirleau, J L'utilisation du plasma ou serum animal chez l homme, plasma ou serum universel detoxique, Presse med 54 883 1946

Co Tui Wright, A M, Mulholland, J H, Barcham I S, and Breed, E S The nutritional care of cases of extensive burns, Ann Surg 119 815 1944

Creed A suggested treatment of extensive superficial burns, with the view of avoiding subsequent scarring Austral Med Cong Tr 1 417, 1909

Curtis L The Skin Grafting of Burns Surg Clin of North America, Philadelphia Number, Philadelphia Saunders, 1947, pp 1466 1485

Dennison W M Treatment of burns and scalds in children, Lancet 237 1107, 1939

Edwards C R, and Bowie, H C High tension electric burns Am J Surg 47 299, 1940

Elkinton J R, Wolff, W A, and Lee, E W Plasma transfusion in the treatment of the fluid shift in severe burns Ann Surg 112 150-157, 1940

Elman R Merry C R, Beguesse, C E, and Tisdale R Severe burns clinical findings with a simplified plan of early treatment, Surg, Gynec & Obst 83 187, 1946

Erb I H, Morgan E M, Farmer, A W The pathology of burns Ann Surg 117 234 255, 1943

Evans E I and Bigger, I A The rationale of whole blood therapy in severe burns a clinical study, Ann Surg 122 693, 1945

Farmer, A W Early treatment of burns, Surgery 15 144 152 1944

Fleming R M and Rezek, P R Sarcoma developing in an old burn scar, Am J Surg 54 457–465 1941

Fox C L Jr Oral sodium lactate in the treatment of burn shock The Journal, Jan 22, 1944 p 207

Freiheit J M The clinical application of the knowledge of RH factors Connecticut M J 10 975 1946

Glover D M and Sydow, A F Fifteen years of the tannic acid method of burn treatment, Am J Surg (N S) 51 601 619, 1941

Goodman J H J, Meehan, J, and Frankel, R Capillary permeability in relation to acute anoxia and to venous oxygen saturation, J. Clin Investigation 26 1119, 1947

Gordon, R A Intravenous novocain for analgesia in burns, a preliminary report, Canad M A J 49 478, 1943

Gordon, S D, and Gordon, R A Thermal burns, Canadian M A J 48 302, 1943

Green, J R Burns Defined or Visualized, South M J 38 822 827, 1945

Gruskin, B Chlorophyll—its therapeutic place in acute and suppurative disease Preliminary report of clinical use and rationale, Am J Surg (N S) 49 49 55, 1940

Gurd, F B, Ackman, D, Gerrie, J W, and Pritchard, J E A practical concept for the treatment of major and minor burns, Ann Surg 116 641 657, 1942

Hamilton, J E A comparative study of local burn treatments, Am J Surg (N S) 58 350, 1942

——— Modern burn treatment, with special reference to a new dressing "foille," Industrial Med 10 427, 1941

Harkins, H N Local treatment of thermal burns, Ann Surg 115 1140 1151, 1942

Hayden, R Present treatment of wounds and burns, J Internat Coll Surgeons 7 179 192, 1944

Hull, H C Treatment of burns of thermal origin, Arch Surg 45 235, 1942

Keeley, J L Gastrointestinal ulceration following burns Am J Surg (N S) 45 85 92, 1939

Kirkham, H L D Observation on the management of burns, Am J Surg 73 210, 1947

Knapper, C Moderne Behandeling van Brandwonden Overgedrukt uit het Ned Tijdschrift voor Geneeskunde Jaargang 90 No 20 Zaterdag 18 Mei 1946

Koch, S L Treatment of Burns A C S, The Panel Discussions

Jellinek S Electrische Ferletzungen, Wien, Barth, 1936

Jentzer, A Traitement biologique des infections Paris Masson, 1928

Kiskadden, W S, et al Wet dressings in plastic surgery, Plast & Reconstruct Surg 3 524, 1948

Lavender, H J Treatment and management of burn cases, Am J Surg (N S) 45 534-538, 1939

Lee, W E Wolff, W A, Saltonstall, H, and Rhoads, J E Recent trends in the therapy of burns Ann Surg 115 1131-1139, 1942

Leonardo, R A Continuous bath treatment of burns, J Internat Coll Surgeons 10 79, 1947

Levenson, S M, Davidson, C S, Lund, C C, and Tylor, F H L The nutrition of patients

with thermal burns Surg Gynec & Obst 80 449 1945
Levenson S M Green R W and Lund C C An outline for the treatment of severe burns New England J Med 235 6 1946
Lustig B Goldfarb A R and Adlersberg D Distribution of proteoses and peptones after intravenous injection Proc Soc Exper Biol & Med 58 No 2 1945
McCarthy M D and Parkins W M Comparative efficacy of blood from normal and from burned donors in experimental burns Arch Surg 53 5 0 1946
MacCollum D W The early and late treatment of burns in children Am J Surg (N S) 39 275 311 1938
McLaughlin R S Chemical burns of the human cornea Am J Surg 74 373 3 1947
Matthews D N The Surgery of Repair Blackwell Scientif Pub Ltd 1943
Mills J T et al The preparation of granulating wounds for grafting a method Plast & Reconstruct Surg 3 245 1948
Moyer C A Coller F A Iob V Vaughan H H and Marty D A study of the interrelationship of salt solutions serum and defibrinated blood in the treatment of severely scalded anesthetized dogs Ann Surg 120 367 1944
Nolan L and Wilson C H More recent ideas in the treatment of burns J M A Alabama 10 156 1940
North J P Electric burns of the head and arm with residual damage to eyes and brain Am J Surg 76 No 5 1948
Owens N Osteoporosis following burns Brit J Plast Surg 1 245 1949
Owens Neal Use of pressure dressings in the treatment of burns and other wounds Surg Cl n of North America Philadelphia Saunders 1943
——— Surgical treatment of burns Use of pressure dressings Read before the 13th Ann Meet of Am Soc of Plastic & Reconstructive Surg New Orleans La Oct 18 1944
Padgett E C Skin grafting in severe burns Am J Surg (N S) 43 626 636 1939
——— Care of the severely burned Arch Surg 35 64 193
Passavant G Continuous water baths for burns Deutsche Klin 1858 Nr 36 38 39 (Quoted by A Rose J A M A 941 Sept 29 1906)
Patton C L The treatment of burns Illinois M J 76 141 144 1939
Penberthy G C and Weller C N Treatment of burns Surg Gynec & Obst 74 428 1942
Phemister D B Contributions of animal experimentation to the treatment of surgical shock Surg Gynec & Obst 86 487 492 1948
Pick J F Dermoplasty of healed burned dorsum of the hand J Internat Coll Surgeons 8 21 224 1945
Pierce W F The use of a sulfhydryl solution in the treatment of burns Preliminary report Am J Surg (N S) 53 434 439 1941
Rhoads J E Wolff W A and Lee W E The use of the sulfonamides in the local treatment of burns Pennsylvania M J Oct 1942
Rosenthal S M Experimental chemotherapy of burns and shock III Effects of systemic therapy on mortality Pub Health Rep 58 513 1943
Rothman M Tamerin J and Bullowa J G M Treatment of burns with 2 5 per cent sulfadiazine in 8 per cent triethanolamine solution *J A M A 120 803 805 1942*
Sheehan J E and Jenney J Continuous epithelisation on large denuded areas Lancet 1 123 1946
Shipley E R and Dodd M C Clinical observations on furacin soluble dressing in the treatment of surface infections Surg Gynec & Obst 84 566 372 194
Siler V E and Reid M R Clinical and experimental studies with the Koch method of treatment of heat burns Ann Surg 115 1106 111 1942
Stewart J D Postoperative shock due to hemolytic streptococcus wound infection Surgery 9 204 1941
Sulzberger M B Kanof A and Baer R L Studies on the acid debridement of burns Ann Surg 125 418 430 194
Sweeney H M The effect of carbon arc radiation on wound healing Surgery 3 12 1938
Tenery R M Extensive cutaneous burns with special reference to blood chemistry changes Surg Gynec & Obst 72 1018 1941
Terrell T C Comparison of foille with tannic acid and tannic acid preparations in the treatment of burns Texas State J Med 34 309 1938
Trusler H M Egbert H L and Williams H S Burn shock The question of water intoxication as a complicating factor blood chemical studies and report of an extensive burn treated by repeated transfusions of blood and blood plasma J A M A 113 2207 2213 1939
Wakeley C P G and McIndoe A H Misuse of tannic acid Lancet 239 627 1940
Wallace A B Treatment of burns Brit J Plast Surg 1 232 1949

War Department Technical Bulletin Surgical management of thermal burns, TB MED 151 March, 1945

—— Use of BAL in oil and BAL ointment in treatment of systemic poisoning caused by Lewisite and other arsenical blister cases, TB MED 104 4 October 1944

Weiskotten H G Histopathology of superficial burns J A.M A p 259, Jan 25 1919

Wolff W A Elkinton J R, and Rhodas, J E Liver damage and dextrose tolerance in severe burns Ann Surg 112 158-160, 1940

Wolff, W A, and Lee, W E A simple method for estimating plasma protein deficit after severe burns, Ann Surg 115 1125 1130, 1942

Wolff, W A, Rhoads, J E, and Lee, W E Recent development in the treatment of severe third degree burns, Nebraska M J 27 369, 1942

Young, F Immediate skin grafting in the treatment of burns A preliminary report, Ann Surg 116 445 451, 1942

21

Surgical Geometrics

Surgical geometrics has to do with the dimensional evaluation of tissue defects, voids and excesses and their reconstruction by collateral tissue or reconstruction by measured ablation of exaggerated form. This becomes possible by application of certain geometrically placed incisions which permit the quantum distribution of tissue masses through maximum application of certain tissue forces (elasticity, contractility and expansibility).

A tissue defect has character of pattern and is composed of parts (anatomic), segments (geometric) and shapes (physical). These are identifiable in terms of length, breadth and depth. In terms of repair or reconstruction the summation of its characteristics determines tissue quantity necessary for replacement or sacrifice.

The repair of tissue voids necessitates the movement of tissue masses. Such transfer of tissue must be done not only parallel with functional needs, but in obedience to certain requisites of form. The latter implies geometric exactitudes in the mobilization of the needed tissue. Hence before any amount of tissue is moved or removed its choice must not only be functionally selective but also geometrically adequate.

Where tissue excesses produce distortions of form and frequently function as well, calculated removal of tissue mass is necessary. This implies geometric delineation consistent with physiologic premise if the formative results are to be predictable, adequate and consistent. A good example of the relevancy of surgical geometrics to adequacy of results is seen in Aufricht's recent approach to the problems of radical mammaplasty (see Chap. 25).

Insofar as the human body itself (or any part thereof) is not only a geometric form but also a viable unit, it is possessed of elasticity, contractility and expansibility which allows for function of its form. The first two are ever present variables of the geometric approach to repair, whereas the third remains as a constant augmentor of mass. Because of its elasticity, viable matter like rubber permits distribution of mass. It is a quantitative form of distribution. This allows for extended coverage of area in obedience with the laws of continuous quantity of mass. But unlike rubber, which is subject to the limitations of Hook's law of elasticity and permanent set, viable matter, because of its capacity for expansibility (hypertrophy or hyperplasia), augments its mass in obedience to the laws of function. This means eventual increase of quantity in response to elastic extension and restitution of function.

Elasticity being a quality of viable matter thus represents a fourth factor or dimension whose presence augments the practical implications of any or all of the three physical dimensions, length, breadth and depth. Its strictly mathematical pursuit is of no practical consequence, (except insofar as it influences the placing of incisions, as demonstrated by Lemberg) and implicates the craftsmanship of surgery with academic irrelevancies in spite of its influence upon basic measurements. Yet precisely because of it, surgical geometrics, as a basic adjunct to reconstruction, becomes one of the most

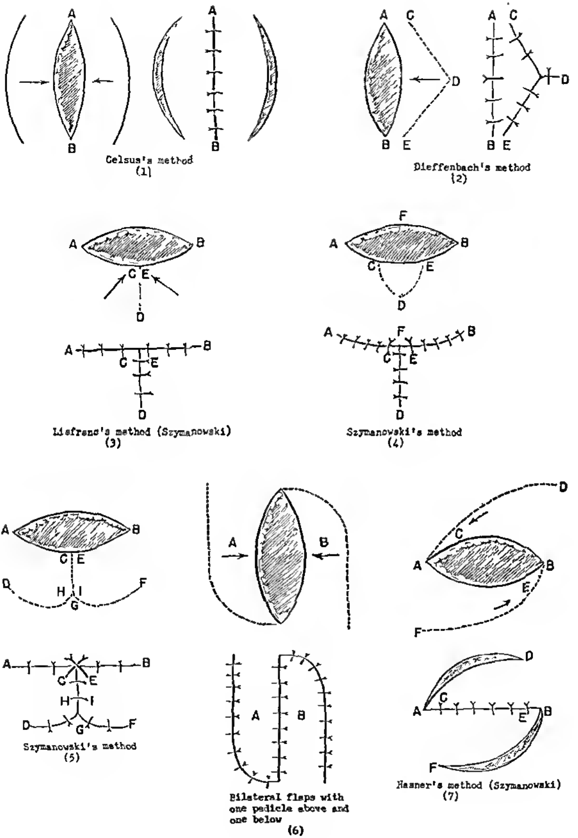


FIG. 186. Linear closures. (For discussion, see text.)

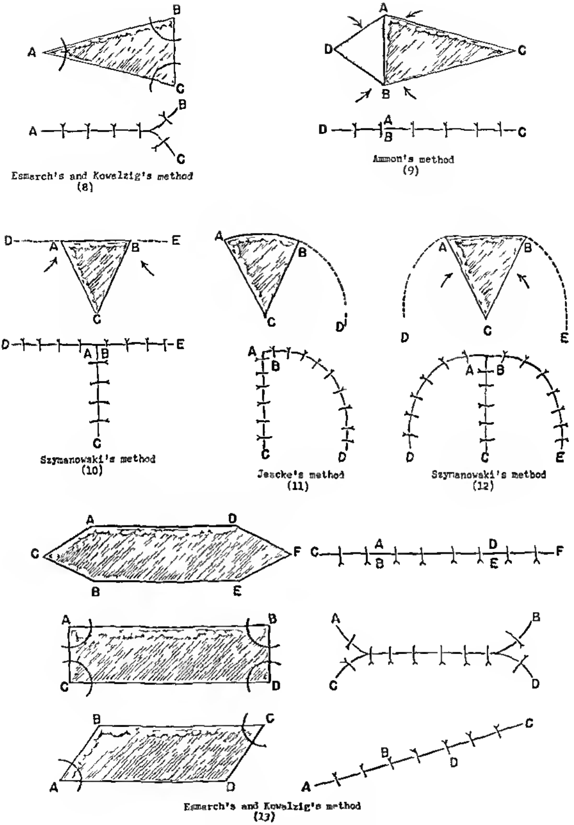
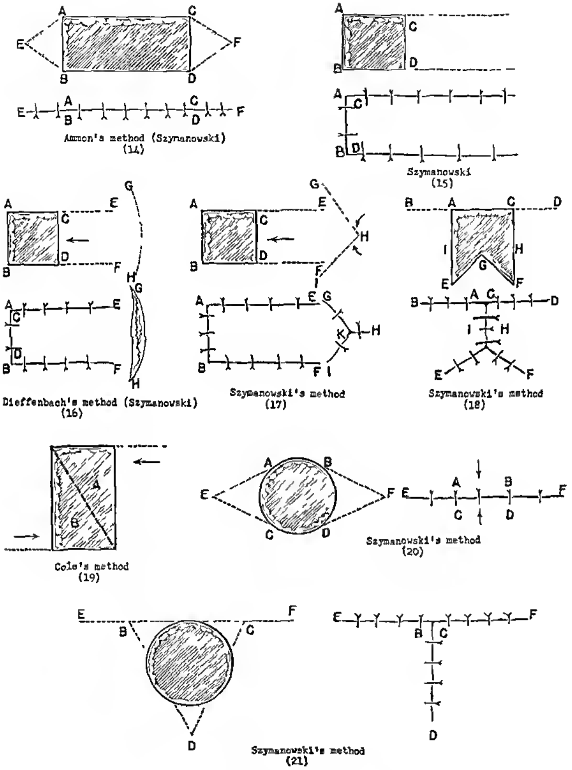


Fig 186 Linear closures (*Continued*)



Ammon's method (Szymanowski) (14)

Szymanowski (15)

Dieffenbach's method (Szymanowski) (16)

Szymanowski's method (17)

Szymanowski's method (18)

Cole's method (19)

Szymanowski's method (20)

Szymanowski's method (21)

FIG 186 Linear closures (*Continued*).

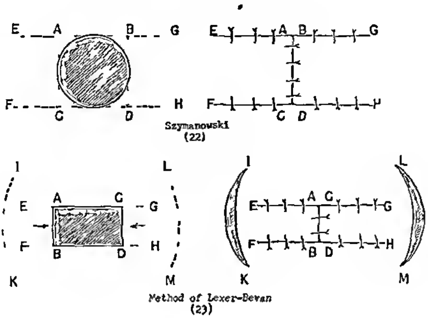


FIG 186 Linear closures (*Continued*)

necessary difficult and interesting facets in tissue repair Without a basic geometric approach to movement of tissue masses there is only a blind beginning leading to the transfer of too much or too little tissue whereas repair based exclusively upon geometric premise may lead to compromise of function by ignoring the variables of elasticity and contractility

To comprehend adequately the nature and the possibilities of surgical geometrics one must reconcile the relationship of tissue elasticity to tissue quantity Elasticity is a constant variable of quantity because of its viable antithesis contractility Either one can reduce or increase respectively the dimensional status of a geometric problem in surgery All these phenomena are evident in the incision or the laceration The insinuation or presence of either immediately alters tissue quantity by affecting its elasticity This situation initiates immediate pathologic changes which with the passing of time become irreversible In other words both tissue quantity and elasticity become permanently reduced because of the element of fibrosis Hence repair in situ becomes impossible with the loss of these advantages Recourse must then be had to the quantum distribution of collateral tissue masses insofar as these still retain the forces of elasticity and expansibility Their maximal application to tissue distribution is in a large measure dependent upon certain geometrically placed incisions This is well illustrated by the Z plasty Its counterpart can be seen in the results following the still too common vertical incision fot tracheotomy

When a tissue is incised (a straight line) it retracts thus resulting in a *defect*—a two dimensional void Given a two dimensional void it can be reduced to a linear defect (suture line) by taking advantage of the elastic component of tissue and so displacing it into the void In other words the premise is that the quality of elasticity (or contractility) being a variable of tissue quantity, can by procedure be translated into dimensional value

The simplest movement of tissue mass is that necessary in the apposition of the lips of an incision Even though it is a two *dimensional* tissue defect, it can be ablated

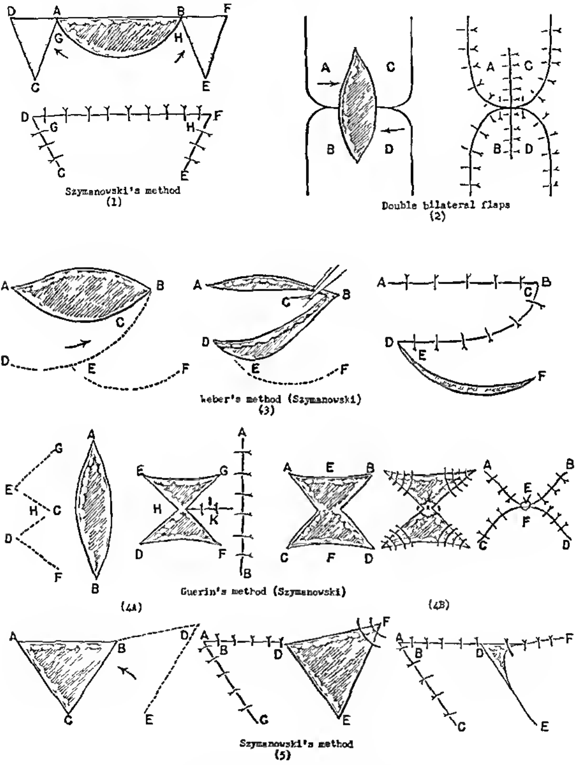
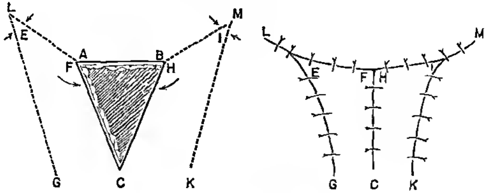
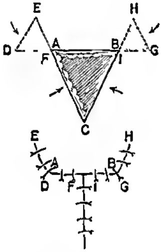


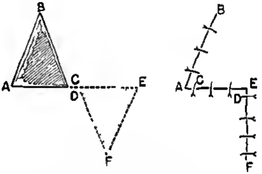
FIG 187 Multilinear closures (For discussion, see text)



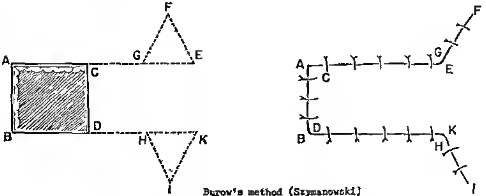
Szymanowski's method
(6)



Burow's method (Szymanowski)
(7)

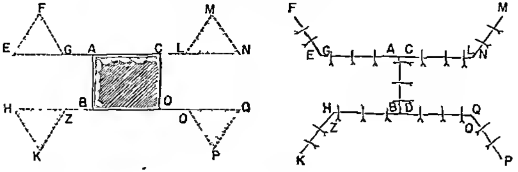


Burow's method (Szymanowski)
(8)

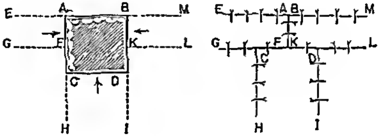


Burow's method (Szymanowski)
(9)

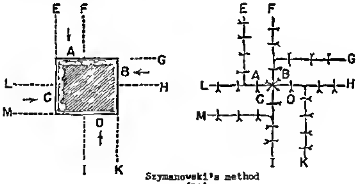
FIG. 187 Multilinear closures (*Continued*).



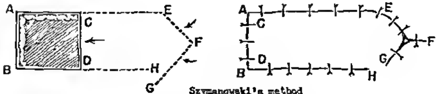
Burow's method
(10)



Szymanowski's method
(11)



Szymanowski's method
(12)



Szymanowski's method
(13)

FIG 187 Multilinear closures (*Continued*).

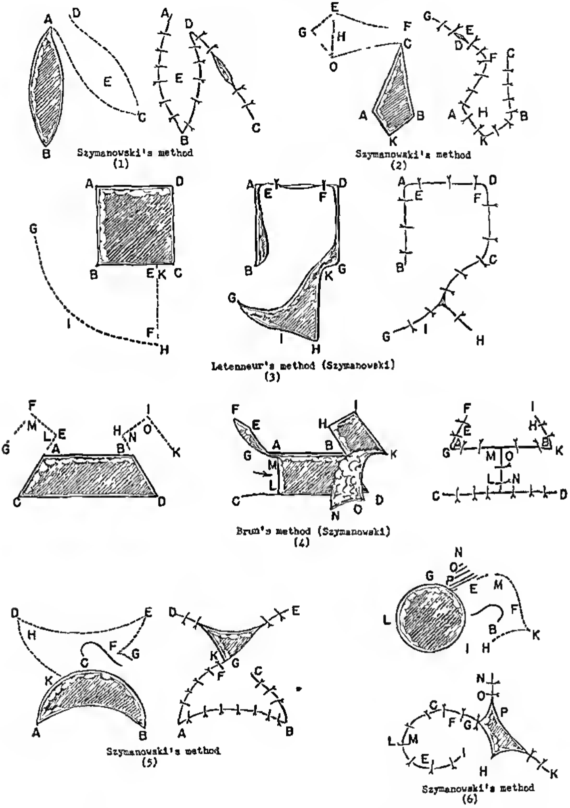


FIG 188 Spheroidal closures (For discussion, see text and Figs 193, 195 and 196, for additional methods)

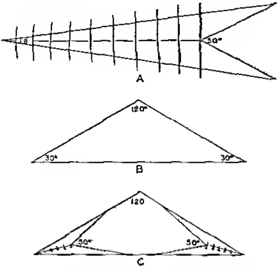


FIG 189 Estimation of limits of closure (For discussion see text, p 388)

without recourse to geometric processes, because of tissue elasticity, thereby being reduced to a linear problem In other words, whereas tissue contractility augments an incision to a two dimensional defect, having length and width elasticity makes possible the reduction of a two dimensional defect into a simple linear problem Where elasticity is absent as in bone or cartilage, strictly geometric ablation is necessary Where the area or pattern of a tissue defect exceeds the possibilities of tissue movement by virtue of elasticity and thus precludes simple closure the latter may still be attained by augmenting the former through undermining This breaks the normal attachment of the tissue and not only permits additional stretching but a degree of displacement Thus a given mass of tissue will cover a somewhat greater area than its purely geometric values would indicate When the potentialities of both elasticity and undermining have been exhausted, actual shifting transfer rotation and quantitative distribution of tissue masses becomes necessary for purposes of wound repair At this point the geometric premise becomes more obvious in the surgery of reconstruction

GEOMETRIC CATEGORIES

Surgical geometrics may be divided into linear problems, multilinear problems and spheroidal propositions The first has to do with unipolar defects, such as cuts and simple lacerations (Fig 186 1 3) The second has to do with multipolar wounds and defects, such as the closure of large squares, oblongs, certain triangular defects, the Z" plasty and other forms of two-dimensional tissue shifting (Fig 187 1 13) The third deals with tissue rotations, transportations, repairs in depth and circular closures (Fig 188 1 6)

LINEAR PROBLEMS

The simplest geometric problems arise in connection with the closure of wide incisional defects—the apposition of tissue units of equal lengths These are almost always unipolar In other words, the resultant closure runs in one major direction and all tissue is directed toward a line connecting the two extremities of the incision or laceration The latter may be referred to as the polarity of the closure after the defect has been repaired

This establishes the first postulate in surgical geometrics, namely, that *any two units*

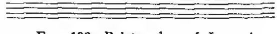


FIG 190 Relationship of Langer's lines of tension to degree of divergence of lips of incisions, when the latter are made at various angles of incidence to Langer's lines Lines of tension are represented by lighter horizontals and incisions by heavy black lines

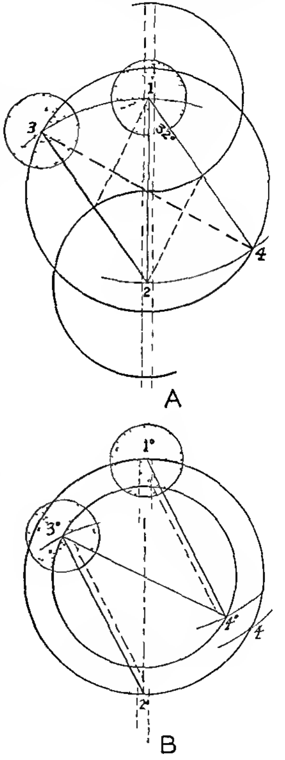
or segments of tissue to be apposed in a straight line should be of the same length and preferably of like tension (Fig 186 1,2,3,4,9,14,20 and Fig 187 1)

As indicated heretofore the size of a linear defect which can be spanned by direct approximation depends, first of all upon the elasticity of the tissues to be drawn together When that quality has been exhausted and undermining adds nothing to it, the lips of the wound must be shifted into apposition The simplest way of accomplishing this, on a linear basis, is to incise on one or the other or both sides of the laceration and parallel to it (maintenance of polarity of repair), undermine the two ribbons of tissue thus created and bring them into apposition (Figs 186 1,2 and 187 2,4A) The resultant surgical defect or defects may be closed by free grafts or further undermining Where the two lips of a wound are of unequal length one has to be augmented or foreshortened to meet the dimension of the other (Figs 186 4 and 187 1) The choice of lengthening one or shortening the other of the two lips of a laceration or incision is determined by the position of the defect or the functional implications of the repair In actual practice it is seldom that one meets with the simple incisional type of defect, except insofar as certain segments of a complex one are visualized and mentally set aside as such (see Fig 202)

The next class of problems amenable to linear closure are certain angles and triangles Any two divergent lines may be brought together by suture, if an adequate amount of tissue elasticity exists But tissue elasticity is a double edged sword

Fig 191 The geometric basis of the "Z" plasty (Lemberg Sheehan) Note relationship of angles of "Z" parallels (2 3 and 1-4 to vertical 1 2 in A) apropos *degree of displacement of points* No 1 and No 2 and coincident foreshortening of line No 3 4 in B, as flaps are transposed As angles increase, so displacement of No 1 and No 2 increases

Where on the one hand it permits movement of tissue in a given direction through stretching, this stretching, being a response



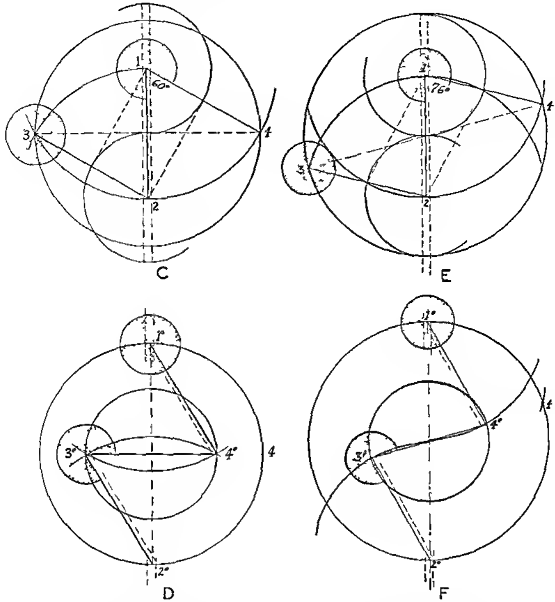


FIG 191 The geometric basis of the "Z" plasty (*Continued*) Further examples of relationship of angles of 'Z" parallels to degree of displacement of points No 1 and No 2 and coincident foreshortening of line No 3-4 As angles increase, so displacement of No 1 and No 2 increases (For application, see Fig 192 and text)

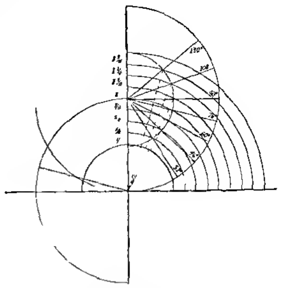
to force, sets up a counter force—contractility This leads to tension upon sutures with the dire consequences well known to all surgeons Through close observation of these phenomena at the operating table it soon becomes evident that *the maximum of permissible stretch is exhausted when the apposition of the lips of a wound has created an angle of divergence of 50°* At that moment the maximum permissible tissue movement or closure has been attained

In other words, since all primary simple closure of wounds is based on apposition of wound edges diverging from a point of origin, the angle, the distance to which the divergent lips of the wound can be apposed

is determined as follows the angle of origin of any two lips is bisected in the direction of maximum divergence of the lips If lines are now drawn from that point of each lip to a point on the bisecting line, so that where the lines cross the bisector they form an angle of 50°, that point is usually the extreme of permissible closure by direct apposition of wound edges

This can be determined beforehand as shown in Figures 189A and C At that point the last approximating suture may be safely placed Beyond that point linear closure is physically difficult, physiologically contraindicated and therefore surgically unsafe This establishes the second postulate in surgical geometrics, namely, ***that no two lips of a wound should be approximated by direct suture whose angle of divergence exceeds 50°*** When that limit has been reached a multilinear closure must be considered, unless a simple relaxing incision permits continuation of the closure

The angles of divergence of any two lips of a laceration or incision, and the diameter of a wound, depend on four factors the length of the wound, its angle of incidence to Langer s lines of tension, the anatomic relation or attachment of the injured tissue to underlying tissues, and the amount of elastic tissue The angle of divergence increases as the length of a wound increases, as its angle of incidence to Langer s lines increases and as its separation from underlying tissues increases (Fig 190) Any one of three factors may modify—and usually does—the other two In other words, if a three inch incision is made parallel with Langer s lines of tension, the angle of divergence of its lips and the diameter of the wound may not be any greater than that of a *one inch* incision made at right angles to Langer's lines of tension In fact, the closure of the former will be easier than that of the latter because of the advantage of the elasticity in the first as against the amount of retraction in the belly of the second incision due to the greater degree of tissue retraction consequent upon severance of lines of tension (Compare A and D, Fig 189) Finally, if the tissues in the case of the incision made parallel with Langer s lines are firmly attached to comparatively immobile tissues beneath it may even be necessary to resort to undercutting of the lips to get sufficient separation for workable surgical approach to deeper tissues



G

FIG 191 The geometric basis of the "Z" plasty (*Continued*) Lemberg's chart, showing relationship of linear displacement of any point on vertical to variation in angle of right flap of 'Z Also relationship of angles of excision to transposition of flaps (For interpretation, see Fig 191 A to F and text)

This brings up a third proposition in surgical geometrics ***the configuration of a tissue dissolution*** (incision or laceration) ***depends upon its length, relation to lines of tension and the integrity of its attachment to subjacent tissue***

From a practical standpoint the foregoing brings up for consideration the fact that an incision or laceration, although unipolar and physically amenable to linear closure, if made at right angles to the normal lines of tissue tension may become a multilinear problem from the standpoint of

repair because of severe tissue retraction The longer such an incision or laceration is the more pronounced this fact becomes If such a wound or incision placed at right angles to normal tissue tension is long enough even if forced physical closure is possible the resultant repair will be at tended by an abnormal amount of fibrous tissue and almost invariably will result in a contracture or hyperplastic scar

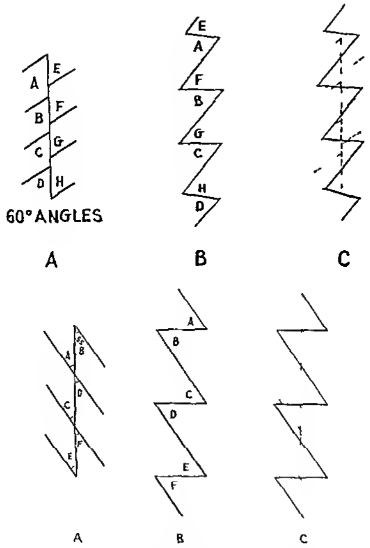


FIG 192A Various patterns combinations and results of the serial Z plasty (after J Staige Davis)

(*Top*) (A) Serial incisions (B) Flaps transposed Note increase in vertical extension (C) Superimposition of B upon A to illustrate relative increase in vertical extension of tissues following transposition of flaps

(*Bottom*) Additional graphic illustration with smaller angles of incidence of Z parallels to vertical

Assuming the vertical to be a contracting scar the above illustrates geometric basis for its relaxation by Z plasty

One of the commonest of these illustrations is the "fiddlestring" contracture which follows the ill advised vertical incision for tracheotomy or a similar incision over the volar surface of a finger Such an unwelcome result is due partly to the forced physical closure and partly to the counterforce to closure The latter force

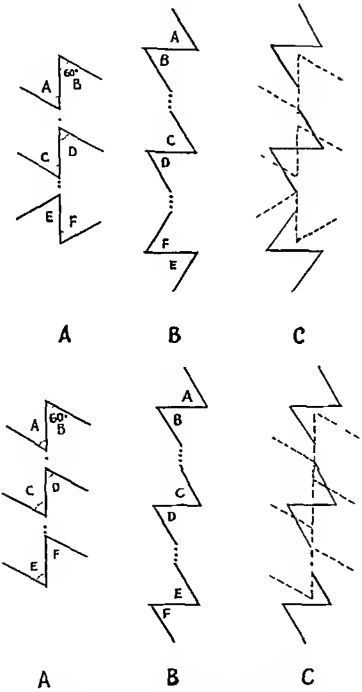


Fig 192B Various patterns, combinations and results of the serial "Z" plasty (*Continued*)

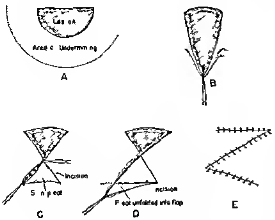


FIG 193 Pick s method of closing a semicircle No tissue waste is incurred here as in Szymanowski s method No 1 (Fig 187) where two triangles are excised and discarded no secondary defects or complicated incisions need to be closed as illustrated in Szymanowski s method No 5 (Fig 188)

persists throughout the period of healing and so long as that force is not stabilized by complete organization of the repair it remains as a biologic irritant to healing hence it results in the persistent deposition of fibrous tissue From the standpoint of physiologic surgery and functional results it is better to close such incisions or lacerations immediately by some form of multilinear repair than to use the usual direct form of approximation This leads to a fourth proposition *a geometric closure of a tissue defect to be both functionally as well as formatively adequate is determined not only by size and shape of the defect but by the integrity and tension of the tissues comprising the closure* This accounts for the diversity of methods recommended by different authors for the closure of triangles squares circles and so on Unless the student bears this clearly in mind he will be tempted to close all defects of a given shape by some one chosen method Early disillusionment would follow As a guide to the selection of proper method it should be stated that the principal geometric approach to the closure of a tissue defect should be based on the points of maximal elasticity comprising the defect

MULTILINEAR PROBLEMS

The difference between linear problems and multilinear problems is both quantitative and qualitative In other words, where as a given triangle or square may be closed by a linear repair, the same type of defect of a much larger size or one incurred in tissue of poor elasticity may have to be closed by multilinear repair because the advancing of tissues used in the repair of the defect may not be possible in a unipolar direction When this problem arises that part of the defect which cannot be closed by simple linear approximation or movement of tissue must be closed by multipolar apposition Additional secondary incisions at other selected points of the periphery of the defect or excision far outside of it have to be made for the purpose of bringing in additional tissue to close the remainder of the wound This is particularly true in defects which are attended by tissue voids due to actual tissue loss rather than to tissue displacement This implies closure of other than simple incisional, secondary defects In fact for the most part they are excisional defects (Fig 187 187 1 187 4A 187 4B 187 7 187 8 and 187 9)

Again the simplest of defects which fall into this category is the linear laceration whose diameter of belly is so large in proportion to the length of the defect that the simple advancement of its lips into the center of the wound is inadequate and the wound must be projected in various directions other than a straight line thus actually resulting in the formation and transfer of flaps (Fig 187)

The surgical defects left after such incisions may be and often are closed by further undermining and direct approximation This is possible only when such incisions are made in obedience to certain anatomic

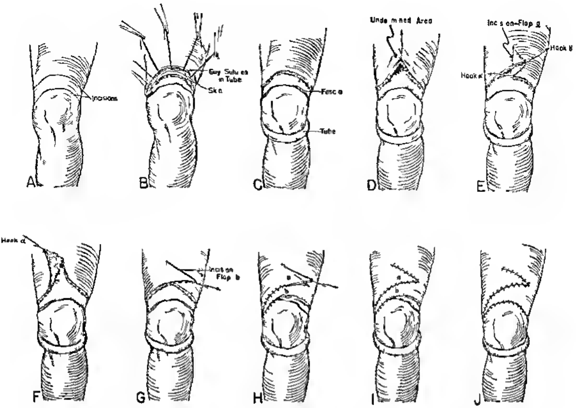


FIG 194A Pick's method of closing a wound with semicircular lips Application of method of closure of arched donor site for suprapatellar tube (For clinical application see Fig 194B)

and geometric postulates (see fourth proposition this chapter) This is eminently illustrated by the so called "Z" plasty

THE "Z" PLASTY

The basic multilinear geometric procedure in plastic surgery is the so called "Z" plasty (Figs 191 and 192) Although the "Z" plasty with its transposition of flaps was first reported about one hundred years ago, it has been rediscovered many times since It was first reported by Denonvilliers in 1856 for the relief of ectropion of a lower eyelid Since then this procedure has been described in connection with innumerable defects, which only proves its almost universal applicability Its apparent simplicity belies its many potentialities and difficulties One of the reasons why its many possibilities are seldom appreciated by the student or neophyte is that he fails to understand its geometric basis, and the mechanics of its accomplishments

The principle of the "Z" plasty is based on the fact that any two points, 1 and 2 (Fig 191), if connected by a straight incision, can be displaced away from each other to a distance equal to the difference between that incision and a line drawn across its midpoint whose extremities 3 and 4 are determined by two other lines, one beginning at 1 and running at a chosen angle to the right of 1 until it reaches 4, the other, beginning at 2, runs to the left of 2 at a chosen angle until it reaches 3 This forms a "Z" When the two triangular flaps thus outlined by the secondary incisions 1-4 and 2 3 are undermined and transposed, the original

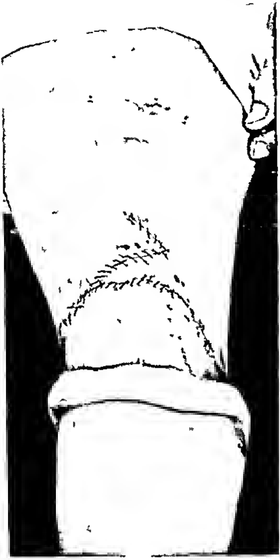


Fig 194B Results of author's method of closure of semicircular donor site for suprapatellar tube (For method, see Fig 194A)

points 1 and 2 will be forced away from each other to the distance mentioned above An optimal angle of 60° was arrived at as a result of the work of Lemberg of Russia who by experiment reduced to mathematical accuracy the problems of the procedure (Fig 191G) The angle of divergence of the parallels of the 'Z' from the central arm may be anything from 15° to 75° or more but in general the 60° angle proves to be the most workable The larger the angle the longer the incisions can be, conversely, the smaller the angle, the shorter the arms of the "Z" should be

Where it is not practicable to utilize the larger angles, the small ones may be used, this allows for the making of so called multiple "Zs" about the polarity of an incision, which procedure is often preferable to remedying a defect by one extensive "Z" plasty This multiple or serial "Z" plasty is credited by Davis to Morestin At least theoretically all the arms of any given "Z" should be of equal lengths (Fig 192)

The above allows for the setting up of a fifth postulate in surgical geometrics *any two points can be displaced in a straight line, away from each other, by a "Z"-plasty to a predetermined distance*

The application of the principle of the "Z" plasty in the conventional form in which it is usually described is fully realizable only in the correction of defects such as congenital webs where no scar tissue has to be excised Where the "Z" plasty is applied to the correction of scar contractures, it does not always fulfill the theoretical promise This is due to the loss of normal relationship of elasticity to tissue mass, therefore, equitable quantitative distribution of the latter is not always possible The former cannot entirely compensate for the loss of the latter after complete scar excision In other words, the central leg of the 'Z' referred to above as 1 and 2 is not a line but a void due to the excision of the contracture It becomes a defect with a second dimension, the latter being the width across the belly of the surgical defect remaining after the scar is excised In such instances displacement of the points 1 and 2 away from each other may have to be augmented by additional undermining or collateral "Zs" The greater the displacement of the points 1 and 2, the more liable are the two flaps to reach across the surgical defect Therefore, the angles should be designed in the case of scar excision and contracture reduction so that the points 1 and

2 are displaced to a degree consistent with the size of the excisional defect the contour of the part affected and the size of the flaps The disadvantage is reduced in the multiple or serial Z plasty In general these conditions usually call for the serial Z plasty with variation of the angles of incidence of the short arms of each Z

This same difficulty arises in the application of the Z plasty to the correction of webs which are actually tissue pyramids rather than flat webs Such a condition is met with in congenital webs which run from the mastoid region over the neck to some point on the shoulder Where such a web joins the neck it has a wide base due to the divergence of the two layers of the web and so forms what for all practical purposes is a pyramid In such cases the Z plasty is limited by its mastoid and acromial extremities and in such variations as are consistent with the concavity of the neck This may necessitate a secondary Z plasty after healing and return of the normal texture and elasticity of the flaps as demonstrated by Esser

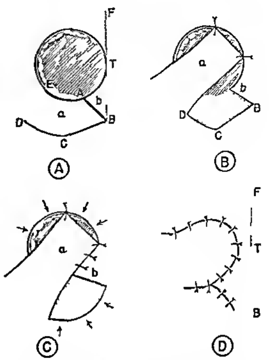


FIG 195 Closure of circle (method of Hadjstamoff) Note necessity for closure of secondary defect Notwithstanding it is a better and simpler method than those of Szymanowski illustrated in Figures 186 188

THE CLOSURE OF AN ARCHEO DEFECT

According to the first proposition in surgical geometrics the apposition of any two lips of a wound demands that they be of equal length Where one of the lips is longer by virtue of being curved or an arc of greater radius than its opposite lip a good formative closure is improbable unless the longer lip is shortened or the short lip is lengthened The former procedure is usually preferable from the standpoint of appearance and is accomplished by the excision of a triangle from the longer side the base of which excision is equal to the difference between the length of the two sides (Fig 186 4) Where it is desirable to lengthen the straight or shorter of the two lips a triangular mass of tissue is excised along each extremity of the curved line the sum of whose bases is equal to the difference between the length of the two lips (Fig 187 1) Such procedures are employed where it is necessary to reduce the closure to a linear problem But the reduction of such defects to a linear problem by the second method is not always advisable particularly where the straight line would run across a flection crease or suspends a concavity This is normally found in the submental region It likewise applies to a convexity such as exists over the shoulder or the tip of the nose

The closure of such a defect necessitates a two-dimensional approach to the problem This permits the obliteration of the tissue void without extension of its polarity in terms of length or the creation of secondary defects A partial solution to this problem has been found by making certain complex radiating incisions away from either the curved lip or the straight one thus permitting the inshifting of the lateral tissues

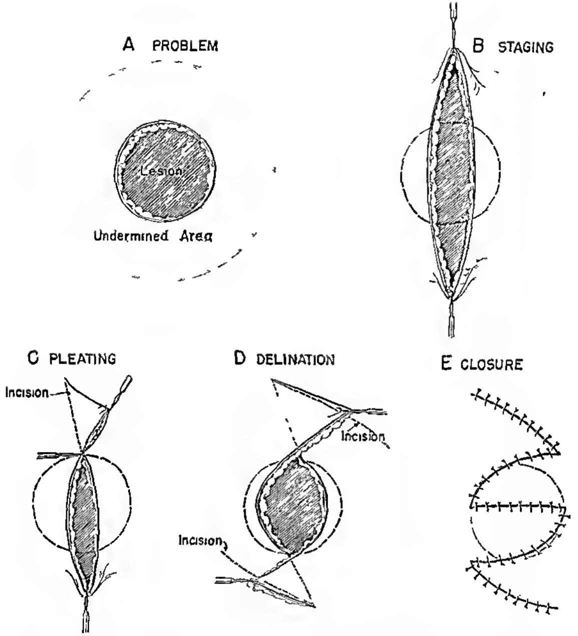


FIG 196 Pick s method of closing a circle After undermining the circular defect circumferentially (A), it is "staged' with two hook retractors (B) This forms a large elevated 'nipple' about each hook A third hook is then inserted into one of the "nipple' lips, the pull being at right angles to a staging hook and at a point approximately tangent to the circumference of the original circular defect (C) This brings the two lips of the nipple together, so that by moving the staging hook to one or the other side a triangular pleat is formed (C) The under side of this pleat is then incised When unfolded, this results in a triangular flap (D) This is then laid flat over the opposing skin (D) The subjacent skin is incised along the short arm of the triangular flap This creates a second roughly triangular flap, which is shifted down into the original circular defect resulting in a donor area into which the first flap (the unfolded pleat) is laid (D and E) This ablates half of the original circular defect The same procedure is repeated over the other pole of the circular defect for the closure (E) This method avoids the difficulties of complicated incisions, the drawbacks of closure of secondary defects and the tissue waste common to procedures of Szymanowski and Hadjistamoff (Figs 186 188 and 195, for clinical application of author s method, see Fig 200A)

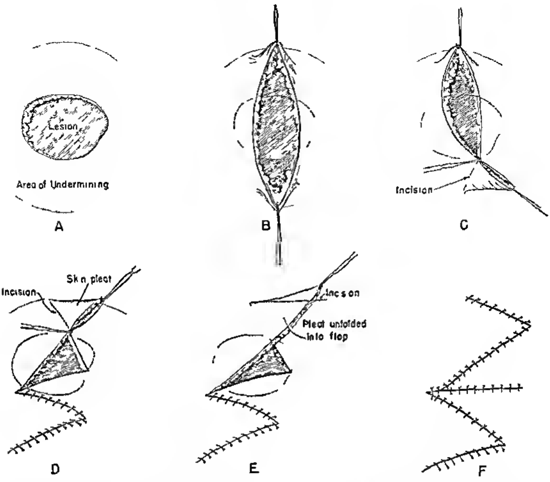


FIG 197 Pick s alternate method of closing a circle The above variation may become one of necessity when the elasticity of the tissues about the circular defect are not diametrically equal In such instances the delineation of the pleats may have to be to one or the other side of a diameter or at times occupy a position in line with two different diameters Where the pleating of both poles must be to the right of the vertical diameter (Fig 196) it is necessary to avoid a three cornered closure of the central flap This necessitates inshifting of the two central flaps, one upon the other, to the extent of two sutures or more as indicated in (F) This is done to preclude gangrene and sloughing of the tips of the flaps due to strangulation by too many sutures in a small area

into the defect This frequently creates a major new defect or two or more smaller ones which then become a special problem (Figs 187 4A, 187 4B, 188 5 and 6) These special problems are prone to stimulate forced closures at the hands of the neophyte

AUTHOR'S METHOD OF CLOSURE

The problem of closure of a defect whose one side is the arc of a circle, or whose *two sides are arcs of unequal radii*, may be accomplished as follows Instead of reducing the arc to the length of its opposite lip, or extending the straight lip to the length of the arc, either of which necessitates the sacrifice of tissue because of the triangular excisions necessary as mentioned above and leads to closure under tension, it is possible to take advantage of the quality of elasticity in terms of a dimension, thus reducing the former quality to *a quantity of mass This concept of the*

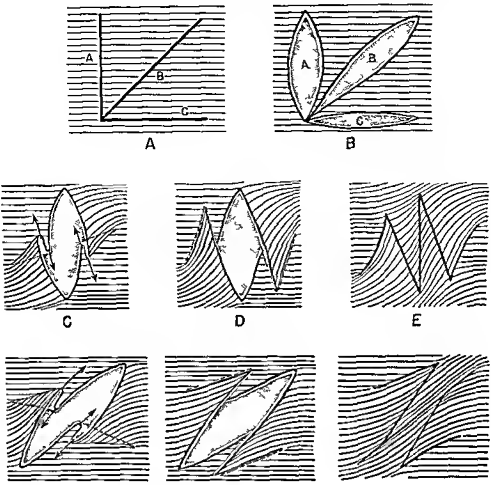


Fig 198 Results of incisions or lacerations across Langer s lines of tension (A) Incisions at various angles to Langer s lines of tension (B) Amount and type of gaping consequent upon incisions at different angles to lines of skin tension Note that incision 'c,' parallel with tension lines, results in minimal amount of 'bellying" (C) First step in the application of author s pleating procedure to the closure of gaping wounds Arrows indicate point of insertion and direction of pull of skin hooks Broken lines denote lines of incision of the skin pleats to produce the triangular flaps shown in D (D) Skin pleats have been incised, unrolled, and are shown spread over underlying portions of lips The elastic component (quality) of skin has thus been translated into tissue quantity, physically greater than the original (see Chap 21) Broken lines indicate position and extent of secondary incisions to form medial flaps to be shifted into wound, permitting closure as shown in E (E) Closure shown completed This avoids tension across belly of gaping incisions or lacerations Note rhythmic alteration of lines of skin tension (F, G and H) Application of pleating procedure to the closure of incision 'b," running diagonally across Langer s lines of skin tension

reduction of a quality of tissue into quantity permits of the disposal of the defect without any tissue cost and without extending the already present defect in a linear direction

If the arched member or lip of the de-

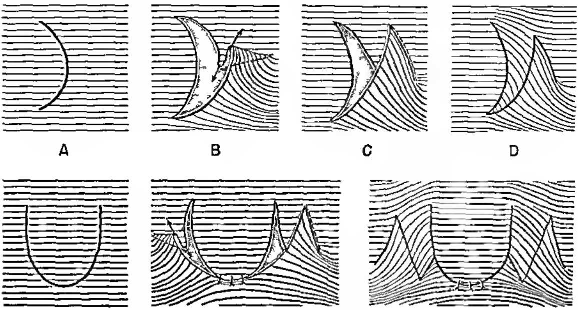
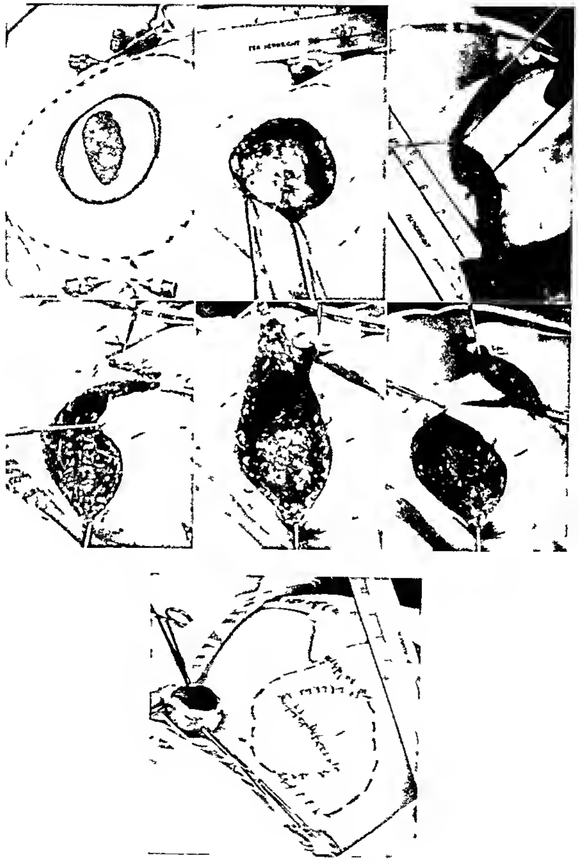


Fig 199 Results of curved incisions or lacerations apropos Langer s lines of tension (A) Curved incision at right angles to lines of skin tension (B) Application of pleating procedure to closure of wound without tension (C) Primary flap completed and superimposed over remainder of lip Secondary incision indicated by broken line (D) Secondary flap shifted into defect and closure completed (E) 'U incision across lines of skin tension (F) Bilateral pleating of lips and making of flaps preparatory to transposition and closure (G) Flaps transposed and closure completed Note breaking of skin tension through re routing of Langer s lines

fect is undermined, thereby augmenting its elasticity to a maximum, it then can be pleated as shown in Figure 193C This changes a semicircle into two potential triangles, one of which (upper in Fig 193C) is a void and the other (the pleat) is tissue excess Elasticity has been translated into mass quantity Instead of excising this amount of "superfluous" tissue, it is incised under the pleat, and an extended triangular flap will be formed as shown in "D" If this flap is now superimposed upon the remainder of tissue within the arc, another incision parallel with the short arm of the first flap can then be made creating a second triangular flap It is this second triangular flap which actually becomes the tissue mass displaceable into the defect The result will lead to a two dimensional closure which in appearance is a modified 'Z" (Fig 193E) When this method is actually applied to a defect whose lips are also curved in the third dimension and are of unequal radii, it becomes a three dimensional closure (Fig 194A and B)

THREE DIMENSIONAL PROBLEMS

The three dimensional problems arise out of implications of the third dimension either in terms of extension of the repair through curvatures, arcs, convexities and circles, or the necessity of rotating tissues from one plane to another In the act of so doing the extremities of a given linear dimension assume new relations to each other and to the whole of the defect In other words, a flap A, B, C, D (labeled clockwise from lower left hand corner), when rotated anticlockwise, does so to the design of a circle whose radius is the



side C D As the rotation increases, so the distance which A B covers decreases, due to unavoidable crowding of B in the direction of A, always resulting in a fold of tissue which has to be excised by secondary revision In consequence, the area which the transposed flap will cover is never equal to the area of the flap itself If, on the other hand, the flap A, B, C, D is being rotated from a flat surface to a neighboring defect whose related side A, B is convex the necessity for elevating A, B over the convexity will "take up" buckling, thus obviating the need for its excision, and in such instances the flap will cover an area more nearly equal to its original extent

If this phenomenon of the translation of a straight line into a convex one (with the saving of tissue) can be seen in reverse, then the translation of a curved line into a straight one should carry with it the possibility of a relative gain in tissue quantity (*see* Author's Method of Closure, this chapter)

FIG 200A Clinical application of author's method for closure of circular defect (*Top row*) (*Left*) Solid black circle illustrates extent of excision in connection with large papillomatous neoplasm of left buttock Dotted circle indicates preoperatively determined area of undermining necessary to close circular defect without nippling or distortion of buttock (*Center*) Neoplasm has been excised down to fascia covering gluteal musculature A thin layer of adipose tissue was left behind to prevent postoperative adhesion of subcutaneous tissue The next step is cleavage undermining to the extent of dotted circle on buttock (*Right*) The circle here is shown pleated by superior and inferior hooks in direction of one of its diameters This is possible as the result of undermining The large nipple produced by upper hook would remain if circle were closed by direct approximation of its edges which in this case would have resulted in excessive tension and post operative breakdown A second hook from top illustrates method of pleating upper pole of defect The crease thus formed to the right of upper segment of defect indicates line of incision in forming first flap of geometric closure Third hook from top is point from which lower pleat is formed and also indicates inner extremity of formation of a lower flap The pleating of the two poles of the defect is augmented by pulling the extreme upper hook toward the side of the antagonistic hook which runs at approximately right angles to the first

(*Center row*) (*Left*) The upper pleat as shown in *top, right* has been incised resulting in a flap which is here shown crossing the right lip of the circular defect held stationary by crosswise hook Note large amount of fat under upper flap When this flap has been properly laid open, as shown, an incision is made above and parallel with it which results in the formation of a second flap on the right side of the defect (*Center*) This illustrates eversion of the first flap resulting from incision of the crease formed at the top of the circle as shown in *top, right* It also shows the formation of the second flap consequent upon the incision made above and parallel with the first flap after being laid upon the right side of the circular defect The second flap is now ready to be shifted downward across the horizontal diameter of the defect and the space left by its rotation will be filled by the upper everted flap (*Right*) The flap from the right upper arc of the circular defect is shown rotated downward and across the wound and the resultant void is being filled by the flap shown everted in *center row, center* This results in the potential closure of the upper half of the circle The identical procedure thus illustrated in *top, left to center row, center*, is repeated in the lower half of the circle This results in two additional flaps identical with the upper two which ablate the lower half of the circular wound

(*Bottom*) The closure of the circular defect is completed It is a serial "Z" closure which dispenses with tension nippling, or deformity of the buttock Note shifting of the left as compared with the right side of the original circle still indicated by broken lines Also observe that the upper extremity of the closure does not reach beyond the flat surface of the buttock into the intergluteal crease The excised tissue containing the neoplasm is shown to left of closure (see Fig 200B)

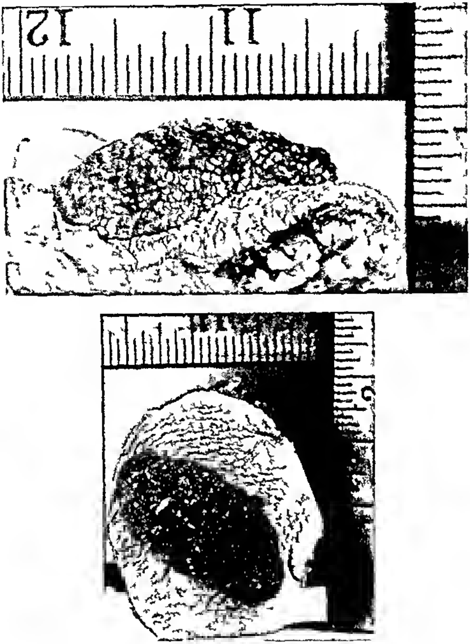


Fig 200B Size and extent of excision of tissue from left buttock (see Fig 200A)

The modus operandi resides in the fact that in the case of flap A B C D a plane is being rotated unto a convex three dimensional surface at least on the A B side whereas when the procedure is reversed and A B becomes a straight line a relative gain in coverage is made It is the old geometric rule of the relationship of the area of planes cubes circles and spheres to surface occupied In other words the higher the dimensional category of a given mass the less surface does it occupy Conversely by reducing a three dimensional object to a two dimensional area the more surface will its component sides cover This is amply illustrated in the opening and the

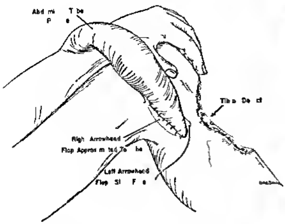


FIG 201 The most convenient carrier position for transfer of abdominal tube This type of arrangement needs a minimum of splinting and postoperative care Adhesive about thigh and forearm with elastic bandage over hand is adequate Note additional quantity of tube necessary (span) to reach and cover recipient site To take advantage of this relatively comfortable position for tube transfer a compromise is necessary between patient s comfort and time and tissue cost Obviously three more surgical innings or steps are needed for completion of the repair (1) transfer of the wrist peduncle to upper pole of defect (2) transfer of inferior peduncle to lower pole of defect and (3) spreading and imbedding of tubal tissue One of the foregoing steps could be eliminated if the tube were long enough so its inferior extremity had reached the lower pole of defect This means double the tissue cost or a much less comfortable carrier position The latter involves heavy plaster splinting and with many patients gross discomfort Generally it is best to keep tissue cost at a minimum the patient s comfort at its maximum and consider time as expendable

spreading of tubes and resolution of large webs by the application of the Z plasty The latter implies dimensional reduction

It was stated at the beginning of the chapter that elasticity and contractility are ever present variables of simple geometric values in surgery The fact was brought out that the geometric category of a defect can be raised or reduced by these qualities It was then shown in the closure of arched defects that the quality of elasticity could be translated into tissue quantity Hence the projection of this proposition should be applicable to the closure of a circle

The Closure of a Circle

The closure of a circular defect is the most difficult geometric problem in plastic surgery Its adequate formative as well as functional closure has been a long sought after advantage Many methods have been devised for its accomplishment Szymanowski Kirschner Lexer Hadjistamoff and others have devised methods of closure based primarily on procedures of tissue cost and the creation of secondary defects as shown in the appended illustrations (Figs 186 20 21 and 186 5 6) Hadjistamoff of

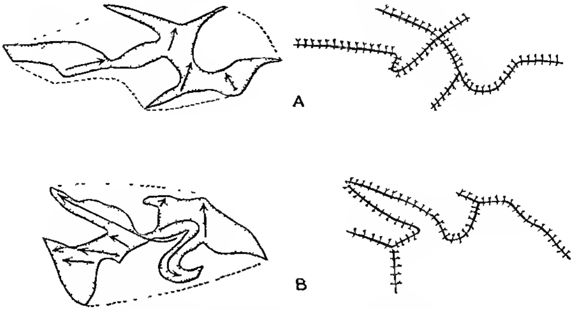


FIG. 202. Closure of lacerations. Dash line about lacerations indicates extent of undermining (Examples are exact patterns of actual lacerations.)

Bulgaria has recently proposed another method of closure, the basis of which is akin to the others (Fig 195). All these methods have one misgiving in common: they leave secondary tissue defects of triangular, pentagonal or hexagonal shape which are almost as difficult to close as the circle, either because of their shape or number

Author's Method

The closure of a complete circular defect or a perfect circle can be accomplished by applying the concept of elasticity in terms of a dimension In the closure of a circle the elastic quality of tissue is translated into tissue quantity

This is accomplished by undermining as far as necessary the entire circumference of the circular defect Some one point of the undermined circle will then be found as a most elastic fraction thereof. This is elevated in the form of a pyramid by a hook as shown in Figure 196B. The elevated tissue is then pleated over on itself as in the closure of a semicircular defect. The infolded facet of the pleat is then incised as indicated in Figure 196C. This forms a triangular flap which, when superimposed upon the remainder of the arc of the circle, allows for a second incision parallel to the distal extremity of the flap, thus creating a second flap. The latter can then be moved into the circle, thus filling up an area usually amounting to about one half the circular defect.

A point is then selected and elevated diametrically opposite to the first one chosen, and a similar procedure is executed thereon, permitting the centripetal shifting of additional tissue into the circular defect. If the elasticity of the skin at the two aforementioned points is adequate to the area of the circle, the latter can be totally obliterated by this simple procedure. Where the total area of the circle is so large or the elasticity of the surrounding skin inadequate to cope with it, a narrow oblong area at right angles to the polarity of the procedure remains This can be ablated immediately by certain additional incisions, inshifting of tissues from the remaining two poles of the

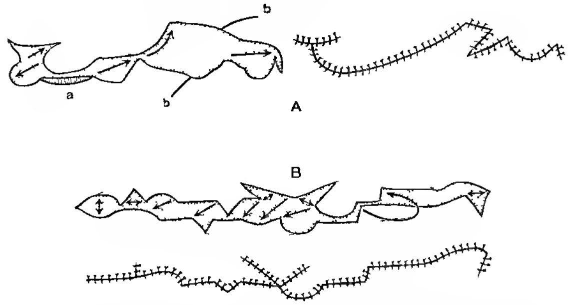


Fig 203 Closure of lacerations (A) Multilinear problem reduced to linear closure by studied excision at *a* and incisions at *b* and *b* This also avoids a straight line closure (B) Linear closure accomplished by gathering of angles into rays (actual reproductions)

circle or by free grafting and a secondary operation after the integrity and the elasticity of the original tissues have been augmented

The foregoing suggests a sixth proposition in surgical geometrics *when the quality of elasticity is translated into dimension it can by surgical procedure be expressed quantitatively in terms of transposable tissue mass* The practical implication of the above proposition resides in the fact that it reduces tissue cost in surgical reconstructions

The most useful application of this method will be found in the closure of three dimensional or spheroidal defects For example given a lesion involving the entire area of skin covering the mandible it is a common practice to advance the tissues from the neck on to the region of the mandible In the advancement or the rotation of the cervical tissues the latter actually have to go through and subserve a three dimensional space which is created by the convex protrusion of the mandible If this is not taken into account the resultant repair may be a distortion of the concavity of the submandibular region or the convexity of the cheek

If instead a straight submandibular incision is now made say from the region of the lobe of the ear to the submental region and the cervical tissues are undermined an arched lip can be raised The lower lip of the cervical tissues can then be pleated and incised as is done in the closure of a circle Through the application of this method a triangular cervical flap is thus created which can be advanced upward over the region of the mandible filling an area consistent with the size of the flap and its elasticity If the original submandibular incision and its extent are properly calculated the size of the flap made available to be shifted over the mandibular area or the area of the cheek becomes geometrically adequate to a surprising degree The final advantage of this method is that it can be so planned as to result in simple one stage multilinear closures entirely consistent with the normal tissue tension and contour of the part There is little fear of buckling tit forma

tion or rippling of one or another edge of the flaps, because this is already resolved in the original pleating of the elevated tissue Since the ultimate transfer of the flaps is in a unipolar direction (by advancement) necessitating little or no rotation, rippling should not occur

PROBLEMS IN TISSUE TRANSPORTATION

The dimensional implications of tissue transportation are things of practical import which should be impressed early upon the student Some elemental illustrations will be cited at the risk of oversimplification

Whereas certain dimensional gains may be realized by taking advantage of the phenomena of elasticity in the transfer or rotation of tissues certain geometric losses on the other hand are sustained because of the inherent contractility of tissues The latter is pre eminently illustrated in the life cycle of scar tissue If for instance a flap is accurately measured to fulfill the requirements of a defect and that same flap necessitates delay to augment its circulation, or if a tube is designed which has to be transported some distance to its recipient site, strict geometric calculations in the donor site may prove to be inadequate from a quantitative and formative standpoint This is due to the fact that a quantity of tissue once divorced from its original environment is subject to contraction and shrinkage It is therefore necessary, particularly in the designing of tubes that a greater mass of tissue be mobilized than seems actually necessary in the reconstruction of a defect Even after the tissue is transported and placed into the recipient site throughout the period of its organization which may last anywhere from six weeks to several months, additional shrinkage of that tissue may occur From clinical experience it has become apparent that all pedicle tissues shrink on an average of one sixth of their original size The final amount of shrinkage of tissue even after its imbedding in the recipient site is not completed until organization of the repair has taken place This, as stated, may range anywhere from weeks to several months The extraneous factors influencing tissue shrinkage, as has been indicated in the section on Principles, are to a large degree dependent upon the amount of surgical trauma, the method of mobilization of the tissue, its postoperative care and the manner of transportation Therefore, it is well for the student to know in the planning of any reparative procedure involving the importation of tissue from distant parts the necessity for mobilizing a tissue mass exceeding the requirements of the defect by approximately 30 per cent This also means the selection of a donor site which can afford the tissue loss without functional embarrassment In doubt, mobilize more than seems necessary

To the above, in both the use of massive flaps or tubes, must be added the geometric factor of span The latter is the amount of tissue necessary in the form of a peduncle which must be allowed for in order to span the 'carrier " If the tissue is transferred immediately, as in the case of massive flaps, the additional tissue necessary as a peduncle may be spoken of as the span This in terms of tissue cost may be reclaimed in primary transfers by replacement of the peduncle in its original bed, but where tissues are transported to any distance, as is the case with tubes, several regions may have to be spanned before the tissue reaches its ultimate destination Every span means a sacrifice of a certain amount of tissue This is often reduced in large measure by the selection of the 'carrier" (Fig 197) (See Chap 16, "Skin Grafts and Grafting)

When the tissue has reached its ultimate destination, the recipient site, it may still have to traverse a convexity, a joint or a space necessary for the purpose of dressing or splinting This, in terms of tissue cost, is its most expensive span This distance from 'carrier" to recipient site must be accurately determined prior to the original mobiliza-

tion of the donor tissue If this is not done it may be found that the practical aspects of dressing etc necessary in the final span will become embarrassing Finally the amount of tissue available for reconstruction without recourse to pulling stretching or forceful implantation may be made quate

terable form One of the outstanding examples of the latter is evident in the making of a tubed pedicle If a tubed tissue is intended ultimately to be used in a two dimensional or flat surface and yet the tissue for one reason or another is allowed to remain in tubed form for long periods of time difficulty is experienced in trying to

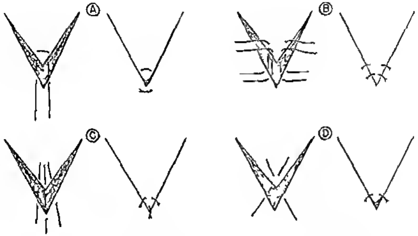


FIG 204 The V closure illustrating various methods of wedging of flaps The danger in A lies in shutting off blood supply of the tip and eversion thereof if the suture is tied too tightly (B) This avoids the objections in A and C This gives maximal accuracy of apposition (C) The central suture must be tied very lightly or it may slough out or produce necrosis of tip if too bulky (D) This is the safest method of wedging if sutures are placed so as to advance tip of flap into position As shown the tip is made quately advanced because the sutures are at improper angle Suture exits should lie on or below level of point of defect

Whereas the elasticity of immediately transferred tissue is equal to its contractility the same does not hold true for tissues which have been transported or waltzed several times The same holds true for re delay of tissues in the form of flaps The more times a tissue is delayed waltzed or jumped the greater the loss in elasticity of that tissue If repeated often enough the factor of contractility of tissue exceeds its elasticity until the latter becomes a comparatively minor factor in the planning of a repair and contractility takes the permanent form of organization of that tissue in unal maintain the finally opened tube in flat or concave shape For a long time the tubed tissue will have a tendency to return to the tubed status Occasionally this tendency remains permanent

PRACTICAL APPLICATIONS OF SURGICAL GEOMETRICS

INCISIONS

From what has been said it must become obvious to the student that even the closure of the ordinary surgical incision may become a difficult geometric problem This arises out of the fact that as a rule surgical

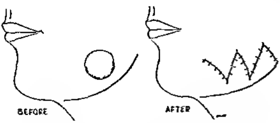


Fig 205A Defect over mandible after excision of tumor and postoperative suture line by Pick's method of circle closure

incisions are dictated purely by expediency of approach to surgical pathology Yet from the foregoing it must be obvious that what originally started out as a straight line incision may not necessarily end up as a straight line closure It may become a two or even a three dimensional problem if that incision has cut across various lines of tension This is due mainly to the fact that the contractility of skin varies in different regions and is partly due to the amount and the quality of the elastic tissue within a given unit of skin also partly due to the fact that the normal lines of tension of skin vary from one region to another

If then the extent of an incision is such as to cover two or more regions of different skin elasticity contractility, and lines of tension the effect may not be a simple separation of the two lips of a wound but a complex geometric defect whose closure may be more difficult than its making

For such reasons the long straight incision of the general surgeon is frequently inimical to the work of the plastic surgeon As indicated heretofore one of the outstanding examples is the vertical incision still frequently made for a tracheotomy approach Even though relatively short it is difficult of closure and when closed it must be done under force against maximal retraction of tissue consequent upon the transection of the normal lines of tension in that region of the neck Even after such an incision is closed it rarely, if ever, gives adequate formative and esthetic results, because in the process of healing the closure acts as a counterforce to the normal force of retraction of the neck tissues and so remains a biologic irritant To avoid this condition, therefore, it is far better immediately to close what started out as a straight incision in the form of a Z' plasty or two-dimensional closure To execute such a closure the surgeon must at least be conversant with the geometric implications of the Z plasty (Fig 198)

It is not to be construed from the above that certain simple and time proven approaches to surgical problems in depth should be discarded in favor of complicated incisions which in themselves prove to be a greater mental burden to the surgeon than the operation itself, but rather that a recognized surgical approach and the closure of that incision are not necessarily one and the same simple problem Whereas a simple mechanical or physical approach to a surgical problem may make the exposure and the surgery simplicity itself simple closure of such an incision may nonetheless result in unwelcome functional or formative results The important thing for the student to remember is that although certain proved approaches to operations in depth should be retained for reasons of practical mechanical expediency, progress in surgery resides in the appreciation of the principles facilitating functional and formative repair of any surgical approach

Lacerations

The principles enumerated under incisions and their closure apply even more formidably to accidental lacerations The ultimate aim in the closure of any laceration is to realize the best functional and formative results possible Such closures can only be accomplished if based upon established premises of physiologic anatomy often materially aided by a knowledge of surgical geometrics

In other words, if a laceration runs across a flection crease, its obliteration must be

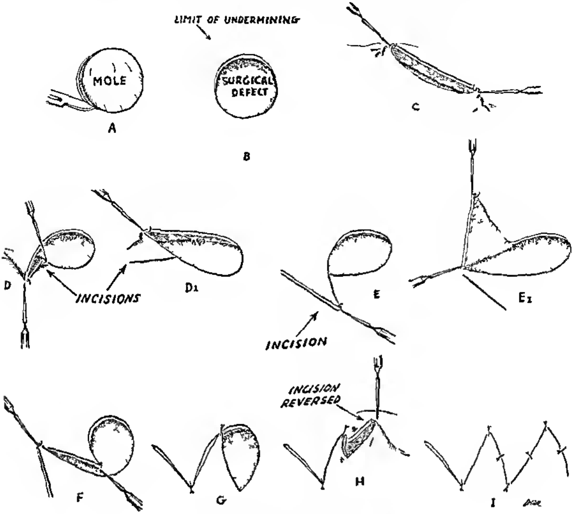


FIG 205B Steps in the rhythmic closure (Pick's method) of a circular defect (see Figs 196 and 197)

consistent with the *function and the form* of that part rather than with ease of closure In such instances the laceration must first be analyzed and subdivided into its component parts This diagnosis must be based upon the requirements and the essentials of function and form of the part as well as upon lines of tension Such components of the laceration as *have no obvious relationship* to form or function may be closed in linear form Such other components as do obviously involve form or function may present themselves in terms of angles triangles arcs or circles If the angles have equal sides they may be closed as a line or if the opposite lip has a triangular wedge projecting into the laceration this may be insinuated into the aforementioned angle resulting in a V (Figs 202 204) If it is an arc or a circle it may by appropriate incision add tissue into the defect This may take the form of a Z plasty in one case or the application of a pleating closure in an other Where the elasticity of a tissue permits it may even be possible to do guarded excision of various parts of the laceration in order to create patterns which are easiest of functional closure As indicated heretofore the angle and the triangle unquestionably *are the most simple patterns* amenable to

simple closure The application of these principles is shown in Figure 200A

Where a laceration involves tissue in depth the same principles of geometric closure apply except that they must be visualized in the third dimension

less symmetric Y Its closure is simplest when the Y scar runs with the lines of tension It then closes as a T It is more difficult when the Y scar runs across the lines of tension In that case the pointed flap must be undermined and advanced or

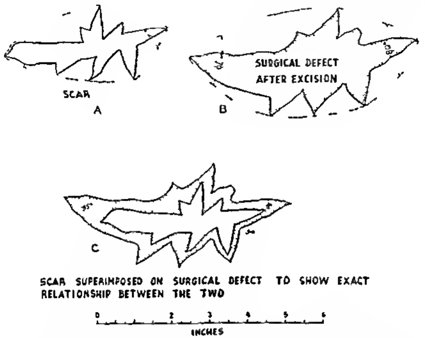


FIG 206 Pitfalls and tissue cost involved in elliptical excision of scars as compared with geometric excision (A) Broken lines indicate minimal extent of elliptical excision Note angle of potential divergence of contemplated lines of excision and compare with actualities in B (B) Scar has been excised on geometric instead of elliptical basis which would create defect indicated by broken line Note size of surgical defect as compared to scar in A Lines of divergence of angles would have increased from 55° and 70° in A to 70° and 80° in B Now compare A and B with C Whereas the angles of incidence of the lips of a projected elliptical excision in A or B preclude the possibility of direct apposition of the lips because they exceed 50° in (C) none of the angles exceeds 35°

EXCISIONS

The most common excisions presenting the problem of closure to the surgeon are those associated with small Y shaped scars or lesions and those in connection with round moles pigmentations and small ulcers The Y shaped lesions should be boldly excised as such because the resultant defect (excision + retraction) is a more or

wedged into the angle below thus resulting in an actual Y closure (Fig 201)

The circular defects left after the excision of moles may be closed by the author s method (Fig 205B)

The usual approach to the excision of a scar by the occasional operator is based upon the principle of creating a simple excisional defect such as an elliptical type

because of the customary belief that these are the easiest of closure This is a logical conclusion based upon a false premise The student is warned against it The excision of a scar is a far different matter from the elliptical defect which follows an incision or even the excision of a *unit* of normal tissue The release of tissue collateral to a scar by the excision of the latter embodies within it potentialities never existent in the excision of relatively normal tissues such as that effected in benign tumors

To begin with the presence of a scar is proof of a pre existing tissue defect Its original size and shape can often only be surmised until such time as complete excision of the scar has been accomplished The proper functional and formative closure of this original defect is the essential problem involved Therefore the motivation behind the excision of a scar should be the deliberate reconstitution of the original defect and its adequate repair rather than the creation of a deliberate surgical defect whose closure seldom conforms to the functional or formative needs of the part This proposition may be accepted as almost axiomatic It again is well illustrated in the excision of a fiddlestring contracture running across a flection crease Its designed excision in the form of an ellipse and its simple closure remains contrary to the aforementioned proposition

Further, with such premeditated excision of a scar a certain amount of normal tissue is sacrificed which can be conserved by a geometric excision of the scar and ultimately used to good advantage in the proper closure of the resultant surgical defect, which is more or less consistent with the original laceration (Fig 206) As indicated in Chapter 18, Surgery of Scars ' only scar tissue should be excised to release the collateral tissues into their normal positions Not to release properly all tissues is to defeat the purpose of scar excision Obviously, the simple elliptical excision of a scar cannot accomplish such tissue release particularly when it is designed with the one purpose in mind namely of approximation rather than actual repair There is no easy road to repair if it is based upon functional and formative requirements The prominent scar as a matter of fact is not only evidence of injury but too often the price of easy closure

Consequently the important thing for the student to remember is that the laceration and its final scar may be just as much the result of an originally poor repair as the causative injury Its proper reconstruction must go back to the original defect with all its inherent problems and cannot adequately be resolved by the insinuation of a new defect the simple surgical excision

BIBLIOGRAPHY

Cox H T The cleavage lines of the skin Brit J Surg 29 234 1941

Davis J S Present evaluation of the merits of the Z-plastic operation Plast & Reconstruct Surg 1 26 38 1946

——— Plastic surgery Its Principles and Practice Philadelphia Blakiston 1919

Davis J S and Kitlowski E A The theory and practical use of the Z incision for the relief of scar contractures Ann Surg 109 1001 1939

Davis J S and Traub H F Plastic surgery Lewis Practice of Surgery Vol 5 Hagerstown Md Prior 1930 Chap 8

Hadjistamoff B A plastic operative procedure for the repair of large circular and elliptical body surface defects Plast & Reconstruct Surg 2 362 367 1947

Harkins H N A new type of relaxing incision —the dermatome flap method Am J Surg (N S) 59 79 1943

Rubin L R Langers lines and facial scars Plast & Reconstruct Surg 3 147 1948

Smith F Multiple excision and Z plasties in surface reconstruction Plast & Reconstruct Surg 1 1 0 1946

Stevenson T W Release of circular constricting scar by Z flap Plast & Reconstruct Surg 1 39 1946

Webster J P Mastectomy for gynecomastia through a semicircular intra areolar incision Ann Surg 124 557 575 1946

22

The Full-Face Graft

One of the outstanding problems in plastic surgery is the complete defacement or destruction of the skin of the entire face. Such a misfortune, though comparatively common in wartime, is not rare in peace time practice. It is most often the result of a third-degree burn involving the entire face which has been allowed to go on to scar formation. Or it may be the complete tattooing of the face by gunpowder, disseminated epithelioma or a hairy nevus covering most or all of the face. To allow any one of these extensive conditions to go untreated is to ask the individual to live with an intolerable defect.

ORIGIN OF THE PROBLEM

The problem originates on four counts: (1) the large amount of skin coverage necessary for an entire face, (2) the habit of reconstructing large skin losses by repeated partial free grafting, (3) the effect of repeated grafting on orifices and (4) the difficulties of social integration of a patient with such an affliction.

The total coverage of an entire face in the average individual involves a matter of approximately 100 square inches of skin. The easiest approach to the transplantation of such an amount of tissue is in the form of a free graft. There are serious difficulties in this, as will be shown presently. The mobilization of pedicles for complete coverage of the face presents the stumbling block of adequacy of donor areas with appropriate skin quality and the necessity for regrafting of the donor areas by split grafts.

The habit or tendency toward repeated free grafting of selected areas of the face until the entire affliction is resolved is not at all satisfactory. The main objections to this procedure, which has been tried often, are several. First and foremost is the fact known to all plastic surgeons that for many reasons any anatomic part which is grafted in stages, and particularly where free grafts are used, will result in an appearance almost as strange if not stranger in some respects than the original affliction. Skin transferred to a locality in sections at different times will eventuate in a patchy quiltlike appearance, due to the fact that no two of the free skin grafts can be depended upon to retain the same shade of color after healing. Even though the successive stages of the operation be done by the same surgeon, under the same conditions, with the same care and even with skin taken from more or less the same donor site, the risk remains that each and every graft transferred on separate occasions will have a different appearance and color. As indicated before, this results in a defacement which is as strange as the original condition (Plate 9).

Another objection to the foregoing procedure is that it is very time-consuming. For instance, following the grafting of the forehead, it is usually considered good practice not to graft the upper lids and the nose until at least two or three months have elapsed, so with each successive stage from temple to nose to lower lids, to cheeks, to jaws, to lips, to chin and neck. A certain minimum of interoperative time must be allowed which prolongs the ultimate solution of the entire problem to as much as three or four years.

A third objection to this type of pro

cedure is that when the time arrives and an adjacent area must be grafted to one already completed a certain amount of the previous graft has to be excised in order to dispense with the scar tissue comprising the edge of the former graft thus providing an adequate bed for the graft which is to parallel it This injects the problem of superfluous tissue cost due to excision of part of the former graft

The final objection to the partial method of procedure is that with every subsequent surgical re entry or attack upon the face that much additional scar tissue is formed eventually resulting in asymmetry of expression of the face (Plate 9)

The third factor which makes the full face defect a problem is the matter of maintenance of adequate orifices and the elements of expression In the case of the free graft the eyelids the mouth etc have to be splinted for several months (tarsorrhaphy and cheilorrhaphy) to avoid deformity from shrinkage of the free grafts It is a prosthetic and kinematic problem of considerable magnitude

The fourth factor social re integration of the individual is really the basis of the entire problem The strange appearance of patients afflicted with full face defects leads to social and economic difficulties which in most cases are insurmountable without some type of surgical intervention

NATURE OF THE PROBLEM

The nature of the problem is the adequate functional and formative restitution of the human face From what has been said it is obvious that partial repeated grafting is not reliable from a formative and esthetic standpoint Something akin to a one stage reconstruction would seem to be a better solution to the problem Since repeated free grafting is not satisfactory and pedicle reconstruction is not practical another approach must be found

Whatever the method it must be founded on certain basic considerations These are of two categories subjective and objective

As concerns the one stage full face graft the subjective considerations involve the immediate welfare of the patient such as the length of the operation its effect upon the body economy of the individual the danger of possible complete failure with its resultant disastrous effects the maturation time of repair and finally and most important such basic functions as respiration deglutition feeding and vision Obviously the extent of the operation is so unusual that all of these functions must be jeopardized to some degree if for no other reason than that of adequate splinting

The objective considerations have to do with determination of the source of the skin conservation of the muscles of expression during the operation special consideration for the orifices such as the nostrils the eyes and the mouth In a male patient the choice of graft must be consistent with the desirability of a beard in later life

Finally the matter of size and form of the graft must be considered Since the operation is based on the one stage principle the thought seems logical to use a one piece graft After some trial runs with chamois it was found that such a graft was inadvisable Its proper meticulous fitting into the many details of the face necessitates so much incising and excising of the body of the graft that the result resembles two or even three separate grafts hung together at certain points by narrow bridges of tissue These bridges of skin are so minimal in consideration of the graft as a whole that it is more practical to use individual sheet grafts (Full drum Padgett 4x8 in) Three of these will suffice for almost any size face These can then be patterned and fitted together on the face in accordance with its details (see below Methods)

TYPES OF FULL FACE DEFECTS

For purposes of completeness full face defects may be divided into acute and

chronic Under the acute type falls the totally burnt face Its coverage in accordance with accepted procedure obviously demands early free grafting Under chronic types belong the cicatricial deformity of the face the neoplastic face (disseminated epithelioma, nevus) and the benign defacement (tattoos, extensive pocks, pigment disturbances)

METHODS OF FULL FACE GRAFTING

ONE STAGE TOTAL FREE GRAFTING

The Totally Burnt Face As indicated heretofore these cases demand early free grafting (Fig 207) They stand apart from other burns in that thicker grafts are preferable on the face (0 02 to 0 026 inches), and because basic functions (respiration and deglutition) have to be provided for in postoperative management, as in the case of other extensive burns The choice of donor area depends somewhat upon the sex of the patient In men the graft which covers the lower third of face and the neck may be from a hair bearing area The best donor areas for the forehead and the upper face are the hypochondria After grafting is completed some form of splinting must be devised which answers the many technical problems peculiar to facial reconstructions (see Fig 74A) Among other things this involves the problem of feeding For one week this is best accomplished by a tube After the first dressing (from 7 to 9 days) the patient may feed or be fed by spoon The diet should be soft during the second week

The Elective Case This type may be the malignant or benign type of defacement, including epitheliomas and tattoos

PREOPERATIVE MANAGEMENT First of all, the patient must be apprised of the seriousness of the operation its extent, implications and possible complications Because of these the patient must ultimately be left to decide the issue himself

One of the first things to be done in the management of these cases, and particularly in the case of the individual with a completely tattooed face, is to biopsy several parts of the face for the purpose of estimating not only the nature of the tattoo but its extent in depth This gives much needed information, both from the standpoint of possible muscle involvement as well as the nature of the bed which must be accepted once the affected skin of the face has been removed This is particularly true in the face tattooed with a vast number of foreign bodies, because if large numbers have penetrated beyond the deep layer of the subcutaneous tissue, the probability is that they cannot be removed without serious injury to the muscles of expression, innervation or circulation of the face This being so, it becomes apparent that the surgeon, after denuding the face, is going to be left with something less than an ideal bed for grafting The large number of foreign bodies remaining in the deep tissues of the face in such a condition and the fibroses already present about these foreign particles should be a warning that one is going to be faced with technical problems after the operation

A good functional reconstruction of such a face dictates a full thickness skin graft Theoretically, this should only be placed upon a perfect physiologic bed, which obviously cannot be the case where a great number of foreign bodies must be left in the deep tissues after excision of the skin Secondly, since one is forced to leave such foreign bodies in the deep tissues, sooner or later, some of these will begin to come to the surface through the graft and so produce small local necroses, if they occur early enough postoperatively, they may endanger the entire project If, finally, the several biopsies performed on different parts of the face show that these foreign bodies are too extensively prominent all over the face, this alone may mitigate against the venture of total free grafting in one operation

The full face graft (*Top, left*) Preoperative appearance of patient afflicted with full face tattoo due to gun powder and steel particles Biopsies of 5 different facial areas showed foreign bodies to have penetrated facial muscles The right eye is functionless The patient requested complete removal of the facial skin because of public mortification (*Top, right*) Skin and subcutaneous tissues for forehead, temples and upper lids reflected nasalward but still hinged to face in zygomatic areas Free graft for this region (0 03 m) taken from left hypochondrium, shown basted to forehead through hairline with openings already made for eyebrows Dark areas on under side of avulsed facial skin, as well as in depths of frontalis, due to foreign bodies which could not all be removed because of circulatory complications Also observe rubber catheter in nose as oxygen feed, when, to allay anxiety, the patient was given I V pentothal for several minutes every hour to supplement local 2 per cent procaine analgesia (*Center, left*) Allocation and making of openings for eyebrows in upper facial graft, after latter had been sutured into hairline Removal of tissues of middle and lower thirds of face begun (*Center, right*) The graft of upper face completely sutured in situ, including upper lids Note eyebrows protruding through graft They were not excised with the remainder of facial tissues, so as to act as important points of anchorage (splinting) and sources of known blood supply for center of graft The free graft for lower face shown ready for approximation Note openings for nose and mouth (*Bottom, left*) Full face graft completed with lip sutures left long and held by surgeon s band, later used as splinting sutures tied to outside of acrylic mask used as a "dressing" for the entire face Observe separate graft used for nose Also completed bilateral tarsorrhaphy and procaine syringe in surgeon's right hand (Time of operation, 7 hours, 44 min (continuous) Operating room team 1 surgeon, 3 assistants, 3 nurses, 1 technician, 2 photographers, 2 anesthetists and 1 water boy] (*Bottom, right*) Patient 15 months postoperative Left eyebrow still in need of revision Note patient's ability to close eyelids Also observe second arm patch graft along left corner of mouth and its deeper pigmentation than rest of face Difference in color is one of the basic reasons for avoiding multiple grafting of the face Secondary graft (done at another Army hospital) necessary 8 months postoperative because of tightness about corner of mouth Patient seen 3 years postoperative much improved in appearance, contented and working

Plate 9

FUNCTIONAL EVALUATION OF THE FACE

Where a face is literally tattooed with hundreds of foreign bodies particularly if they are of any size at all it is not unusual to find that certain of the muscles of expression in the face have become so involved by fibroses secondary to the tattooing that they function poorly or not at all This to the experienced eye gives additional evidence of what the probable appearance of the face will be after removing all its covering In other words the probability is that where muscles of expression do not function the muscles are completely fibrosed to such an extent that the consequences of the grafting will only augment the lack of facial expression and this must be explained to the patient and must be taken into consideration before any definite decision is made to operate

This involvement of the function of expression is more prominent in such total defacements as follow healed third degree burns rather than in cases dramatically tattooed

FIG 207A The panfacial third degree tar burn Scalp region is so dark because the tarred skin is still present On the face it has been removed The scalp was leathery to feel rather than in the nature of an Eschar

SPLINTING

Where the patient has freely requested that the operation be performed and the surgeon finds it otherwise feasible to proceed the problem of postoperative splinting must be given adequate consideration before operation

The usual method of splinting of an extensively injured face is the so called pressure dressing Obviously its most difficult application is to the face The dressings must be applied and bandaged not only in a manner consistent with adequate pressure upon the grafts but in such a way that the patient is able to retain some degree of vision ability to breathe and swallow Of course, this can be attained by meticulous placement of dressings about the orifices and accurate bandaging so that a sufficient number of openings are left for the basic functions to be carried on These dressings are difficult to apply and when once applied they have certain drawbacks It is not easy to get controllable adequate pressure on the various parts of the face because in some regions there is underlying bone and in others like the cheek there is not Hence one can never be absolutely certain of the adequacy of such a dressing Further difficulties arise out of the fact that the dressing is not only cumbersome but often frightening to the patient It interferes to a great degree with the necessary drainage from around the orifices which always takes place following such an extensive operation Sooner or later the dressings become soiled odoriferous and wet As a result of saturation the dressing becomes decompressed These things can be corrected to a certain extent by the application of supplementary dressings But this only makes the entire problem more difficult and

annoying for the patient as well as the at tendants who are charged with the feeding and the care of the individual

If any unexpected complications occur such as vomiting or local infection it is im possible to attend to these individual mat ters without removing the entire dressing This is particularly discouraging where such complications arise within the first one hundred hours postoperatively because such early removal of dressings grossly jeopardizes the possibility of success of the total face graft Such a complication can become a calamity

In one of the author s cases a method of splinting was devised which it was felt would allow for the management of such exigencies without jeopardizing the entire face This splint consisted of an acrylic mask which covers the entire face Since the patient was an individual injured in World War II the acrylic mask was con structed by the dental department of a large U S Army hospital with the techni cal help of the engineering section

The procedure used in designing and manufacturing this mask necessitated the making of a very accurate Negocoll im pression of the patient s face With this as a negative a positive of Celerit and Hominit was poured which was then turned over to the dental department The technicians cast the positive in stone negative which later was fitted to the patient s face in order to ascertain its relationship to every detail of contour

This was then translated into a stone positive from which a block negative of stone of sufficient thickness size and weight was constructed so as to withstand the pre calculated pressure necessary in fusing the acrylic into form This form was intended to be an acrylic negative of the face which after meticulous polishing on its inner sur

FIG 207C The panfacial third degree tar burn (*Continued*) Burn after being grafted (19 days postoperative on scalp) White area over left eye is a temporary prosthesis to control shrink age of socket l ning

face would act as a reliable splint for the entire field

The acrylic negative was constructed by the Army Engineering Department attached to the hospital It was necessary to design special equipment for this assignment Among other things it required a pressure of 2 500 lbs to the square inch for its manu facture It was incidentally hoped that in its creation the acrylic would clear suffi ciently so that the grafted face underneath it could be easily studied from day to day

Once the acrylic mask was finished it was cut into three pieces The first cut was made on a level with the external canthi The thought was that if any complications should arise about the eyes or on the fore head only the upper one third of the mask would have to be removed The second cut was made on a level with the corners of the

FIG 207B The panfacial third degree tar burn (*Continued*) Burn free grafted (grafts 0 024 in) in one stage Ten days postoperative Sutures ready to be removed Note complete take of grafts. Tar amalgamated scalp still present Lower photo shows redressing with Xeroform gauze after removal of sutures and skin hygiene

mouth This was done so that either the lower third of the mask could be removed in the case of uncontrollable vomiting or oral complications without disturbing the upper two sections The middle section alone could be removed in case of interference with respiration without disturbing the forehead or the jaw sections of the acrylic mask By means of opposing flanges left on each section as illustrated with appropriate holes drilled through them so that the hole of one flange could be exactly superimposed over the hole of the other flange the three sections were then joined together by bolts (Fig 208)

A large number of holes were then drilled through various parts of the acrylic mask for purposes of drainage and the possibility of topical application to the grafts if necessary These drill holes were one eighth inch in diameter and numbered 36 They were placed in locations which normally act as points of drainage, such as over the lower lids about the nostrils over the cheeks about the mouth and under the jaw These drill holes were all separate and additional to the required openings left for the mouth the nose and the eyes

One of the outstanding technical problems was the movement of the lips their possible retraction during swallowing their displacement during sleep or vomiting For this purpose a double bow of stainless steel wire was imbedded into the acrylic mask so that the ends of the two bows, after being soldered together could be securely fitted into the mask one on each side of the corner of the mouth This allowed the bowed wires to extend in archlike fashion over the

Fig 208 The acrylic facial splint A method of splinting completely grafted face This provides against major post operative exigencies by virtue of possibility to remove any one third of mask at any time without necessarily disturbing the whole It also permits observation of graft under it Note drill holes in various dependent parts to allow for postoperative drainage or irrigation via large needle without removal of mask

Fig 209 The acrylic splint in situ Note wire loop about mouth opening This may be used for lip sutures allowed to extend to outside When sutures are tied to wire loop lips are prevented from moving during process of healing or from retracting during period of graft organization

mouth and beyond the surface of the mask This was for the purpose of tying lip sutures to the wire bows external to the mask, so that adequate tension and splinting of the lips could be maintained cheilorrhaphy was contraindicated (see Fig 209, *left*)

The entire mask was then completed with the necessary straps (with adjustable angles of incidence) so that it could be properly secured to the head (Fig 209)

After the entire mask was completed, it was given a trial The patient s face was covered with one layer of fine petrolatum gauze, and the mask strapped over it The patient was then asked to sleep with the mask one night and report on it in the morning

Preoperative Preparation The night before the operation the patient, if a male, is closely shaved properly scrubbed with soap and water and the face is painted with 1 per cent tincture of iodine The forehead is shaved back for a distance of about one inch including the hair of the temples The face is then sterilely covered and bandaged partly for aseptic reasons and partly to test again the patient s tolerance to the inconveniences of a total face dressing

The Surgical Process On the morning of the operation the sterile dressings are removed and the face is again completely reshaved It is then rescrubbed and finally washed with ether and alcohol No other preparation is deemed advisable

The entire chest and abdomen are prepared in the same manner as the face, to act as donor sites They are then sterilely covered and draped in such a manner that they

can be easily exposed for the mobilization of the grafts

The face is then draped so nothing shows except the features below the hairline and above the thyroid cartilage

Operation

Under local analgesia an incision is started below the hairline and carried anterior to the ears circumferentially around the entire face Following meticulously the line of cleavage between the subcutaneous fat and the skin comparatively little bleeding is encountered Where foreign bodies are encountered deeper than skin the dissection is carried to the cleavage between the two layers of fat The entire depth of subcutaneous facial fat never must be excised or severe nerve injuries will result and important muscles of expression will be sacrificed The eyebrows are also excluded in the excision of the skin These are ideal islands of anchorage for the graft about the eyes

When the dissection has reached a line on a level with the lower lids a free full thickness skin graft (or in our case a one 0 027 inches in thickness because of situational difficulties cited) is mobilized from the right hypochondrium under intravenous sodium pentathol The latter may be discontinued when the graft is being sutured into its recipient site This is brought to the upper part of the face already dissected free of its tattooed skin and quickly basted into position below the hairline

This having been accomplished the skin of the remainder of the face is as meticulously excised to below the point of the chin Throughout the dissection the facial skin is conserved in toto Technical problems may arise in this region In the case illustrated while denuding the nose it was found that the skin over the left upper lateral cartilage and part of the alar wing on that side was deeply adherent to the lining of the nose This was partly the result of a mass of foreign bodies in this region and secondly it was due to a former nasal accident which had left the upper lateral cartilage on the left side so destroyed that little if any of it was interposed between the tattooed skin and the mucous lining of the nose In consequence of this situation a minimal perforation of the nasal mucosa occurred This opening was closed with fine chromic catgut

A second technical difficulty which arises in all cases is the necessity for dissecting more superficially in the nasolabial triangle in order to conserve the muscles of expression In any case this may be difficult for two reasons first because of the presence of rather large pieces of foreign bodies secondly due to the obliteration of fine outlines of the facial muscles as a result of fibrosis secondary to the presence of the foreign bodies

A third technical difficulty is the unusual number of large arterioles found in the region of the cheeks This necessitates slow and meticulous dissection with repeated ligation of bleeders Of these there may be from 30 to 40 in the lower part of the face which have to be ligated separately with fine catgut As a rule the dissection of the remainder of the lower face progresses uneventfully

In the case cited the tattooed skin of the entire face was removed in one piece with the exception of that portion overlying the lower left half of the nose which had to be excised separately due to the difficulty mentioned above

As soon as the lower facial skin is completely removed another free skin graft is mobilized from the left hypochondrium and transferred to the face The graft which falls below the level of the upper lid must approximate almost full thickness skin in contrast with that falling over the forehead which may be a thick split graft (0 02 0 026 inches as indicated) This again is quickly basted into position in preparation for final meticulous apposition of the entire grafted

area The latter is accomplished with individual fine horse hair sutures after proper incisions are made to accommodate the two eyebrows which are not excised the eyes the nasal orifices and the mouth

A bilateral tarsorrhaphy (which may be done as a separate prior operation) is then performed Five long double sutures are applied to each lip to be tied later to the stainless steel wires incorporated in the mask outside of the mouth

After thorough irrigation under the graft and removal of all blood clots the entire face is covered with one layer of Xeroform gauze over which is fitted the acrylic mask The aforementioned oral sutures are then tied to the steel wire bows in front of the oral opening so that the lip margins are distinctly visible in the opening The entire mask is finally strapped to the patient s head

Fig 210 Totally grafted face (15 months postoperative) Note areas immediately adjacent to corners of mouth These are secondary grafts which were necessary because of postoperative tightening of cheeks This was avoided in subsequent case by inserting intraoral appliance preoperatively which maintained cheeks in state of bulge The secondary grafts were added to the face by surgeons at another Army hospital They clearly illustrate the objections to multiple grafting The difference in color of the secondary grafts and the remainder of the face is obvious Apropos the basic purpose of full face grafting the secondary experience proves the main objection to serial grafting and lends support to the need for a one stage procedure Note minimal derangement of lip vermilion (See Plate 9)

Postoperative Care

The patient is accorded all the care comfort and observation consistent with any major surgery After sutures are removed the patient may use cocoa butter cream for 2 or 3 months to keep the skin soft and pliable He should avoid sunburn or freezing (Fig 210)

The Full Face Graft

Advantages

1 One stage operation
2 Hospitalization—minimal
3 Tissue cost—minimal
4 Economic cost—minimal
5 Complications—optimal

Disadvantages

1 Operating time—6 to 8 hours
2 Esthetic—fair to good
3 Long period of organization
4 Functional—fair to good
5 Late postoperative corrections—difficult

Combination of Pedicle and Free Graft

Insofar as objections remain to the free graft method and since the extreme alternative to complete free grafting of the face—pedicle grafting—is not advisable for the

eyelids and the forehead and since the latter method involves maximum tissue cost and time a combination of the two is the only other alternative

This involves a multistage process A separate pedicle in the form of a tube should be prepared for each side of the face and a third one for the nasolabial triangle to avoid a suture line running vertically down the middle of the face The best donor sites for the tubes are the pectoral regions first and the inner arms second

At an opportune time during the preparation of the tubed pedicles the forehead and the eyelids are free grafted by thick split grafts or preferably full thickness thin skin This may be done at one time or in two stages For reasons given under the preceding method it is best to do it in one stage

The pedicled tubes when ready are then transferred to the face and are allowed to remain attached by both peduncles at some predetermined sites until ready for spreading It is best to open the two and spread these at one and the same time This allows for better balance and symmetry of form in reconstruction

Where the pedicle tissue joins the free graft of the forehead the eyelids and the temples it should be thinned out by removing the subcutaneous tissue Failing that there always will remain a distinct formative transition from one type of graft to the other Because of the improbability of pigment match between the two types of grafts the transition points are only accentuated by difference in thickness of the two

Combined Pedicle—Free Graft Method

Advantages

1 Operating time—planned
2 Esthetic—good to excellent
3 Period of organization—optimal
4 Functional—good to excellent
5 Postoperative corrections—minimal and easy

Disadvantages

1 Multistage operation
2 Hospitalization—maximal
3 Tissue cost—maximal
4 Economic cost—maximal
5 Complications—proportionate to number of operative stages
6 Scarring of parts used as donor sites

Finally because ultimate functional results are better assured the combined method of full face grafting is the procedure of choice

BIBLIOGRAPHY

Steinreich O and Callahan A Reconstruction of the face and all four eyelids Am J Surg 74 No 6 1947

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Esthetic Surgery

Esthetics, insofar as it can be applied to surgery, should not be restricted to plastic surgery alone Nor should it be made the sole responsibility of the plastic surgeon Since by definition the word implies that which appeals to the senses—in other words, things in good taste—it may well find more general application in surgery This is true of dressings, splints, original repair, casts, etc It is an imperative part of good pre operative and postoperative care and indis pensable to adequate and finished training of the hospital resident Certainly no time is wasted in making more than ordinary effort to produce better appearing repair and coverage thereof These things rightfully make up the total effect ('l effet total") to which medical historians refer as the art of surgery

The art of surgery as a whole is based upon the same effects throughout These are neither new nor strange to the plastic surgeon Nor is the idea of plastic surgery and all it implies in the reconstruction of the human form a contemporary concept. Its newness resides only in the realization of past hopes Only because of the obviousness of its results is there a greater necessity for accuracy meticulousness and finish in the craftsmanship It is by no means and exclusively a fine art Surgery is more than that It is the embodiment of human hope, faith and morality Therefore, strictly speaking, the term esthetic cannot be ap plied to it in the ordinary sense of its meaning, but for practical purposes and because of common usage, the term undoubtedly has its place apropos the surgery of reconstruction of the human form It is certainly preferable to the term cosmetic sur gery,' which would imply a more colorful and superficial yet unholy purpose to a human proposition deserving of greater re spect and dignity

The necessity for gentleness in the handling of tissues their most accurate ap position and precise anatomic repair applies as much to an intestinal anastomosis as it does to the reconstruction of an eyelid The difference ultimately is situational rather than basic In the case of intestinal anasto mosis the surgeon can subordinate details of appearance to pressure of circumstances whereas in the case of the eyelid he must prove his difficult wares to the scrutiny of all

The nearest that the esthetic approach should and can hope for in surgery is the re establishment of certain relationships of one anatomic part to another and the ablation of obvious blemishes which are commonly looked upon as misfortunes of appearance though these may have nothing to do with the physical function of the part Notwithstanding, they usually have much to do with the individual as a functional whole

Ultimately, the material with which the surgeon works is not easily amenable to any predetermined or preconceived idea of per fect form In the words of Blair, Often the best we can do is not enough ' * This is un avoidable so long as the surgeon must work with material subject to all the variables of viability and healing, viz elasticity, vul nerability, innervation, circulation and scar formation Hence, even though one suc

* Blair V P Surgery, specialty surgery and plas tic surgery Surg, Gynec. & Obst 62 895 898 1936

ceeded in the surgical creation of a preconceived esthetic form there is no knowing or guarantee that that form will remain and stand the test of time and the exigencies of healing since the surgeon has but little control over the ultimate propensities of nature When to this is added the wear and tear of age and the effects of gravity, for instance upon all tissues it is not impossible that the surgeon is only a kind of incidental interloper upon an uncompromising course of events

Esthetic surgery in its practical application must be confined to the problems of symmetry and the relationship of form to function in their reciprocal effects It must be allowed that surgical reconstruction in order to meet the physiologic premise is unfathomable without a sense of proportion and symmetry of execution

Form and function is undoubtedly one of the most elusive problems in reconstructive surgery Corrective procedures for the restoration modification or maintenance of form where it bears relationship to overall function are a legitimate concern of the plastic surgeon The purpose of these corrective procedures is the reconstitution wherever possible of not only the external physical likeness (Brown s Surgical Substitutes) but of such qualities as give preeminent functional promise

FORM AND FUNCTION

Form may be related to function in the same degree as deformity is related to dysfunction This relationship of deformity to dysfunction is frequently difficult to appraise because of the subtle and inherent ability of the body to compensate The degree of compensation for a deformity and the threshold of tolerance in dysfunction are variables Therefore an absolute norm cannot be established and must not be confused with the average Examples of the relationship of deformity to dysfunction (pathology) are legion Because the relation hip is so obvious we are therefore more conscious of its reality than we are of the relationship of form to function (physiology)

Surgeons long ago recognized that bone malformed due to congenital or traumatic causes, will with use assume more or less normal shape This observation led to what is known as Wolff s law The exact meaning of Wolff s law is difficult to interpret and is therefore explained by various authors in different ways but in general, it implies that both the gross and the microscopic structure of bone is influenced by function It might well be said on the other hand that through function the physiologic integrity of any injured or malformed part is improved This leads to an augmented metabolism wherefore bone is able to be reposited in more nearly normal structure and form than it would be otherwise As a matter of fact upon these prerequisites (circulation—metabolism) may depend the ultimate answer to the question as to whether a bone graft per se remains a permanent functional part of the defect it bridges or whether it is eventually substituted by new bone as the physiologic integrity of the part permits (re formation)

Upon closer scrutiny of the principles involved in Wolff s law, it would seem that its implications are not necessarily unipolar In other words it is not only function which influences form, but the influence is reversible and reciprocal There is no argument with the former assertion but in support of the latter an interesting parallel is readily observable in surgery and that is that function often depends upon form These are two extremes of a phenomena which may be stated as follows where there is no function at all eventual and complete atrophy results and therefore cannot even maintain such human form as is purely residual Contrariwise, where there is no form there can be no physiologic function The two extremes reduced to clinical experience leave one with conditions lying between these two extremes In other words there always must be some function and parallel form or else the purposes of operative surgery would be reduced to a paradox One does not operate

on a part where physiologic function is totally excluded nor does one expect function in an anatomically formless part

Neither form nor function can be said to be the direct or exclusive cause of the other as effect For instance no amount of functional exercise will change a congenital deformity into a normal part Finally the degree of function (amount) or at least its quality (kind) are affected by the deformity Only after the surgeon reforms the part can function be augmented or qualified This is self evident in the case of a cleft palate It is as true of less obvious conditions such as that found in asymmetries of the nasal air passages As Proetz points out

> It is not enough that the total capacity of the nasal chambers be sufficient to permit free flow of a volume of air adequate for respiration It is equally important that the two sides be almost alike for if a disproportionate amount of air is forced to enter through one side that side tends to become dry and then develop a metaplasia of the ciliated epithelium At the same time the relatively obstructed side is under ventilated and likewise undergoes changes in the epithelium which differ from those of the over patent side but are equally unhealthy *

In other words the form of the chambers of air passages bears a relationship and influences the integrity of function

This interrelationship of form and function is a basic and fundamental one throughout the animal kingdom Whether one considers the lowly white corpuscle in its first formative stages or the human individual as a whole neither one becomes a complete functional (social and physiologic) unit until its form is completed according to biologic plan The lack of complete form in infancy and the relative deformity of old age are further evidence of the integration of form and function

It may be said that form is the medium through which function makes itself manifest Wherefore the great Dieffenbach for instance considered rhinoplasties in selected cases an effective approach to augmenting the psychological effectiveness of the individual thus making him ultimately of greater social and economic value Attention must be called to the fact that ordinary deviations and irregularities in the external nose have relatively small influence on the function of the appendage unless they are of such an extent as to involve the fossa and so produce changes in the pattern of air distribution The surgical implications of the two will be discussed in this chapter under Categories of Form

Dieffenbach s thesis will be further discussed in this chapter under Plastic Surgery and Criminality

CATEGORIES OF FORM

Form is usually thought of in terms of external internal and dynamic form From the standpoint of the plastic surgeon and parallel with the principles laid down in Chapter 19 Splints and Splinting the external form becomes the esthetic form the internal form becomes the prosthetic form and the dynamic or functional becomes the kinematic form All organs have esthetic and kinematic form but not necessarily prosthetic form The latter is essentially peculiar to hollow organs like the eyeball the bladder the nose and the gastro intestinal tract

The anatomic counterparts of esthetic form would consist of the covering tissues such as skin capsules of organs bone cortex fasciae etc The internal or prosthetic form would then in the main be represented by the tissues which go to make up the lining of a cavity the contents of cavities with attachments and relations The kinematic form would then be represented by the muscles nerves blood vessels and ligamentous constituents of the part

The relationship of the three anatomic counterparts of the categories of form is ultimately the determining factor of the total or overall form of the part (appear

* Proetz A W Physiology of the nose from the standpoint of the plastic surgeon Arch of Otolaryng 39 514 517 1944

ance) A gross disturbance of any one of the three categories of form will influence the other two and concomitantly the function of the part Since many hollow organs do not have a supporting structure in terms of a skeleton its function is taken over partly by the kinematic counterparts of its anatomy and partly by suspensory structures Contrariwise appendages like the hand, which are not hollow organs and therefore have no lining in the true sense of the word, maintain their form through fine muscle balance distributed about the skeleton Finally it should be re emphasized that parallel with Wolff s law which postulates that both the gross and the microscopic appearance of bone (form) is influenced by function it is as valid that both quality and degree of function of a part are influenced by its form (integrity of its tissues) The surgical implications of this are obvious The functional reconstruction of an appendage or its restoration must be based upon balanced and symmetric reconstitution of its component parts by viable, morphologically related tissues of formative integrity

ESTHETIC RECONSTRUCTION

The problems which come under this heading are for the most part made up of tissue derangements and tissue excesses The simplest of these are superficial scars, nevi tattoos depressions and abnormal pigmentations Whether it be an extensive epidermal scar a vitiligo or the failure of normal return of color in a free graft tattooing of the skin as recommended by Blair and Brown may be the only practical esthetic procedure indicated Where the scarring or the pigmentation involves the entire thickness of the skin or is of such a nature that tattooing would prove inadequate, some other form of skin substitution must be devised From the standpoint of appearance the procedures of choice are those based upon the use of collateral skin which is shifted into the defect after excision of the undesirable area The use of free grafts or tissue imported from other and more distant parts of the body is too often inimical to esthetic promise in plastic surgery

Where the importation of tissue is undesirable and tattooing is denied by the patient, any number of so called "cover marks" or make up pomades may be the solution to the problem As a rule, these are temporary substitutes, because sooner or later either the patient tires of their use and application or, because of their relative inadequacy, consents to tattooing or surgery In many cases "cover marks" are irritating

Another outstanding example of esthetic ablation of a tissue defect is the so called cutaneous hemangioma or nevus flammeus This unless too extensive, is amenable to the same type of management as indicated for the foregoing conditions Actual procedures will be described in the appropriate chapter

Under tissue excesses the outstanding and probably most common conditions encountered by the plastic surgeon calling for esthetic reconstruction are the hump nose, the lop ear and the hypertrophic or hyperplastic breast To these may be added the hypertrophic type of facial ptosis In all these conditions a planned excision of tissue is the treatment of choice This always should be done with a view of improving not only the appearance of the patient, but also the function of the part, if possible In any case what function is conservable should be allowed, and under no conditions should a destructive operation be done or advised unless the condition is actually a deformity, where the results of surgery will definitely improve the status as well as the appearance of the patient Accepted and proven procedures for the foregoing conditions will be discussed in the appropriate chapters in Section III

PROSTHETIC RECONSTRUCTIONS

Conditions necessitating prosthetic reconstructions are usually of the order of tis

sue voids and tissue derangements (ablated or collapsed cavities)

Prosthetic reconstructions can be circumvented by the use of so called prostheses From the standpoint of the patient these fall into the class with cover marks, paints and tattooes Sooner or later the patient tires of their use and the need for protection and admits to some type of reconstructive surgery Where the condition is so severe as not to be amenable to surgery, there may be no other choice except to advise the patient to wear a prosthesis In that case it is still the surgeon s responsibility to provide the patient with the best and simplest prosthesis available

Prosthetic surgical reconstructions in a manner of speaking are ultimately a kind of biologic prostheses In contrast with esthetic reconstructions the prosthetic type is not only a matter of appearance but also a matter of function In these cases symmetry of reconstruction is even more important than in the esthetic type

Probably the simplest type of prosthetic reconstruction is that in connection with the scar obstructed nose If the obstruction is due to a local tissue derangement, such as a grossly deviated septum, obviously the reconstruction should be based upon the specific component involved But where the obstruction is entirely due to destruction or loss of the lining, any existing scar tissue must be completely excised, and the nose must be lined with a thick split graft, since enough mucosa is usually not available

Where a gross prosthetic deformity of the nose exists, it is frequently associated with an esthetic deformity of the appendage, consequently, a combined prostesthetic reconstruction of the nose must be done This is particularly true in hockey noses, football noses and fighter noses The procedures employed in these conditions will be discussed in Chapter 36, "Nose," Section III

Another outstanding prosthetic reconstruction is the relatively common cleft palate It is included here because the ablation of the condition does not necessitate the reconstitution of all the tissues normally found in the palate, but simply a reconstruction of the lining of the nose and the lining of the palate The insinuation of any supporting tissues between the two is unnecessary and difficult and only interferes with subsequent function because of too much tissue mass Where it is impossible, because of the size of the defect to reconstitute the lining of the palate it may be necessary to import extra oral tissues for this purpose Such procedures are considered in the appropriate chapter in Section III

The surgical construction of a vagina is another example in point A cavity is made in the appropriate part of the perineum which is then lined preferably by full-thickness skin, and the skin is splinted by some adequate means such as Neal Owens of New Orleans has suggested Procedures in connection with prosthetic surgery will be discussed in Section III One point must be made here and that is that almost without exception all such procedures must be followed by prolonged splinting (3 to 6 mos or more), exceeding that required for esthetic or kinematic reconstructions because of the protracted tendency of all substitute linings to shrink

KINEMATIC RECONSTRUCTIONS

Kinematic reconstructions, total or subtotal, involve tissue defects of all three categories voids, derangements and excesses Kinematic reconstructions are the most difficult They demand exactitudes of technic and precisions of anatomic reconstruction, which calls for special knowledge, special training and much experience This is partly due to the fact that it is a phase of reconstruction of comparatively recent approach It is a form of surgery which has to do not only with function per se, but also with functional expression The form of a part varies with the degree of expression of its many functions It is a form

of surgery where tissue substitution is confined to its minimum. Its greatest stumbling block from a functional standpoint resides in our meager knowledge of the biology of nerve regeneration and the physiology of nerve function.

One of the outstanding and undoubtedly most eloquent examples of kinematic reconstruction is the use of the periocular muscle in the movement of an artificial prosthesis. Whereas the esthetic appeal of a normally moving prosthesis is its most obvious and desirable counterpart, its accomplishment depends entirely upon the incorporation of the kinematic potential of the remaining ocular muscles.

A similar example can be seen in the relative abandonment of the sling operations for facial paralysis and the substitution of such kinematic procedures as the transplantation of portions of the masseter and the temporalis into certain selected points of attachments—the corners of the mouth and the melonasal crease. More normal function and expression are advantages not possible with sling operations.

Although the still frequently employed sling operation for facial paralysis is adequate from the standpoint of prostesthetic reconstruction, their kinematic value is in most cases questionable even where the facial slings are sutured to active muscles such as the temporalis. Parallel with this and in accordance with the principles of physiologic surgery as enumerated in Section I, it is obvious that the use of such inert material as tantalum wire for the suspension of the paralyzed face is not only contrary to physiologic surgery, but can never hope to accomplish adequate kinematic or even esthetic results.

On the same basis the ablation of the harelip by mobilizing a number of cutaneous flaps which are then sutured together with the simple purpose of obliterating of a tissue void remains inadequate from an esthetic standpoint. Proper and complete esthetic reconstruction of a harelip necessitates the mobilization of all available musculature of the lip and the establishment of its continuity. Unless this is accomplished, the otherwise repaired lip always will have a dull expression which eventually will take its toll of the entire mouth. If in the course of such an operation undue surgical trauma or inexpert suturing is used, even the prostesthetic form of the lip will be inadequate and will result in an appendage which is scarred, retracted, flat looking and little more than a tight curtain over the upper teeth. Such a structure can easily be put down as an adynamic lip.

LIMITATIONS

The above coodition can occasionally be seen as a result of nature's own failure to provide certain facial appendages with the necessary kinematic elements. These akinetic entities also frequently follow certain diseases, particularly of the infectious type. Though the muscle tissue or its remnants may still be present in an atrophied form, because of its inadequacy the part in due course of time will not only lose its functional import, but its normal appearance as well. In other words, even though the covering tissues and the lining are present, a lip or a lid whose neuromuscular integrity is lacking sooner or later will change its appearance aod become an unesthetic looking object. To retrieve its original appearance wherever possible, some type of muscle transplantation procedure must be employed. In many cases this is not possible and therefore some form of palliative prosthetic procedure is employed.

The above is particularly true of such unresolved problems as the grossly injured penis. Plastic surgery has little to offer in this connection as yet because of our lack of knowledge and inability to cope with the kinematic necessities of a properly and adequately functioning male sex organ. Such substitutes as the insertion of cartilage into a nonerecting organ is not even a good substitute for its amorous function.

Some of the foregoing examples of the limitations of plastic surgery are discussed, not with the view of making the subject seem too difficult of comprehension and exercise, but rather to impress the student with the unlimited possibilities still extant in this specialty To make tbe simple statement that no part of the human body is today beyond the reach of the surgeon's scalpel is only the beginning of the ultimate answer to the challenge faid bare to modern surgery What is important is the question, What can one accomplish and how best to accomplish it when the scalpel has exposed the void? The earnest student in surgery must not only be tempted to exercise such contemporary privileges of surgery as are required of him by a curriculum which when reduced to a common denominator constitute fine carpentry or plumbing, but rather to be impressed with the necessity and the opportunity for extended effort in the direction of functional prostesthetic surgery Only thus will the surgical neo phyte find purpose and compensation in his cbosen field

The kinematic approach in surgery is particularly necessary in the so called facial asymmetries This is pointedly brought out by John R Thompson, of the University of Illinois, who refers to the lack of proper *dynamic form* as *abnormal asymmetry* He states that

> Asymmetry may be the result of a warping of the growth pattern of the face, destruction of a vital growth center, paralysis and other conditions that exert an influence during the growth period On the other hand, there are those cases of asymmetry that may occur immediately because of the loss of bone from the jaws This type of asymmetry should receive considerable attention from the dental and the medical profession today *

He goes on to say,

> The prevention of these deformities de mands the unified action of the surgeon, oral surgeon, orthodontist or prosthodontist The fact that a man is a surgeon, orthodontist or prosthodontist does not necessarily qualify him to participate in the management of these cases It is only when he has an understanding and an appreciation of the functional anatomy of the head and neck that he can fulfill his responsibilities to the patient †

Thompson obviously has reference to the kinematic reconstruction of facial injuries The implication in his words is that the mere occlusion of the teeth and the inser tion of a bone graft is inadequate in the complete functional rehabilitation of such injured faces Unless the kinematic contents of the reconstruction, that is, proper mus cle balance and tension as well as conserva tion of the neurocirculatory integrity of the various parts is assured, the surgeon bas not ' fulfilled his responsibilities This de mands specific knowledge and experience

Since, according to Thompson, maloc clusion is not one of the causes of asym metry of the face, but rather one of its symptoms, then orthodontic treatment, though it may straighten the teeth will not straighten the face In other words, though esthetic or prosthetic restitution may have been accomplished, dynamic form never will be realized because nothing has been done about the kinematic content of the deformity Since symmetry is the balance of form, tben form to that extent determines quality of function This is only another example of the relationship of and the inseparability of form and function as well as the influence of the former upon the latter

The application of this principle of the dependency of dynamic form upon adequate kinematic reconstruction and the depend ency of function upon form should be remembered and applied in the repair of accidental injuries, particularly of the face and the hands Such repair avoids subsequent invalidism and the almost insurmountable problems of late correction

* Thompson J R Asymmetry of the face, J Am Dent A 30 1859, 1943

† *Ibid*

PLASTIC SURGERY AND CRIMINALITY

The meaning of the esthetic principle in surgery and its possible effect upon human behavior has been applied by the author in an experimental way over a period of twelve years on the inmates of a state penitentiary. Corrective surgical procedures have been done for congenital and acquired defects on the inmates with the view of determining the effect upon the emotional 376 inmates the following conclusions seem to be warranted (Chart 7)

The psychologic results were the most outstanding feature and gain particularly as concerns improvement in general behavior of the inmate long after operation also in the salutary influence this new interest had on other inmates in the institution. Finally there was a gratifying response from the families of the patients which completed a circle of factors all hav

CHART 7 DATA IN CONNECTION WITH TEN YEARS OF PLASTIC SURGERY IN A PENAL INSTITUTION

LOCATION	CONGENITAL	ACQUIRED	NUMBER OF OPERATIONS
Ears	27	19	73
Eyelids	3	9	14
Nose	49	109	207
Face	4	34	45
Mouth Lips etc	5	14	21
Neck	4	11	16
Jaws Palate etc	6	4	14
Chest Breasts	2	3	7
Abdomen (Minus Hernias)	1	2	3
Genitalia	3	2	7
Skin (Minus Common Tumors)	11	189	202
Upper Extremity	7	12	27
Lower Extremity	9	17	29
TOTAL	121	425	663
GRAND TOTAL—DEFECTS	546		663
NUMBER OF PATIENTS	376		663

Statistical record of ten years of plastic surgery in a penal institution

timbre and behavior of this type of individual while in the institution and after release

It is well known to penologists that many individuals *confined in penitentiaries* feel that their incarceration is the result of certain bodily deformities or defacements. I have heard it maintained by many such inmates that had it not been for a certain defect or deformity their situation in life would have been much different

After performing 663 operations on 546 defects both congenital and acquired in ing a bearing on the behavior of the individual during incarceration. The sum total of results has been more encouraging than was anticipated at the outset of the experiment

The sociologic results cannot for the present be stated in full except to say that only 2 6 per cent of the 376 patients operated upon were returned to the penal institution in a period of 10 years. This is markedly below the usual 20 per cent or more as found in official statistics. A recheck of ex inmates has elicited social

readjustments, where the latter had failed through other forms of therapeusis

The following conclusions are set forth on the basis of the above work

1 A physical defect or deformity though usually only a contributing factor to crime, can be a dominant cause

2 The correction of bodily defects in adult inmates of a penal institution strikingly influences their conduct during incarceration This is in accord with the principles of modern mental hygiene

3 *The removal of such defects makes the* individual more confident of his re entry into society

4 The physical rehabilitation of an inmate not only establishes a psychological benefit to his person but has a salutory influence upon his associates and his family

5 Where criminality has become an established habit, in all other ways resistant to rehabilitation improvement in the appearance of an *adult* incorrigible may change the standards of his criminal practices upon release from that of a common thief to that of a specialist of higher order It is therefore felt that where bodily defects or gross features exist in the *youthful* delinquent, who all his young life is referred to as monkey face," fish face dog ears, or limpy, such defects should be corrected and their trigger value removed before the *boy delinquent becomes the man criminal*

BIBLIOGRAPHY

Atkinson D T The artificial pupil in the restoration of vision J Internat Coll Surgeons 9 365 369 1946

Berson M I Rebuilding bony depressions of the face and skull J Internat Coll Surgeons 9 243 247 1946

Blair V P *The consideration of contour as well* as function in operations for organic ankylosis of the lower jaw Surg Gynec & Obst 46 167 1928

Brown A M Prosthetic restorations after *amputations about the hand Am J Surg* (N S) 68 338 343 1945

——— Prostheses for the nose J Internat Coll Surgeons 10 53 62 1947

Brown J B and Cannon B *Full thickness skin* grafts from the neck for function and color in eyelid and face repairs Ann Surg 121 639 643 1945

Brown J B Cannon B and McDowell A Permanent pigment injections of capillary hemangiomata Plast & Reconstruct Surg 1 106 107 1946

Burian F Fysiologicke Operovani Knihtiskarna Tiypus V Praze 1945

——— Plasticka Chirurgie v Ceskoslovensku *Zvlastni otisk z casopisu Ceskoslovensko* 1 c 5 1946

——— La chirurgia plastica ed estetica sua importanza e suoi rapporti con la medicina generale e con la chirurgia Chir plastica 1 No 1 1935

Byars L T Tattooing of free skin grafts and pedicle flaps Ann Surg 121 644 648 1945

Byars L T *and McDowell F Preservation of* jaw function following surgery and trauma Surg Gynec & Obst 84 8 0 877 1947

Castle B Wound closure with a minimum scar J A M A April 24 1909 p 1333

Conway H and Docktor J P Neutralization of color in capillary hemangiomas of the face by intradermal injection (tattooing) of permanent pigments Surg Gynec & Obst 84 866 869 1947

Cornbleet T Removal of cutaneous stains *J A M A Clinical Notes 135 573 1947*

Costa O G Traumatic marginal baldness Brit J Dermat 58 280 1946

Cowdry E V Cooper Z and Smith W Program of research on aging of the skin *J Gerontol 2 51 1947*

Creed A suggested treatment of extensive superficial burns with the view of avoiding subse*quent scarring Austral Med Cong Tr 1 417* 1909

Erdos Brown M Superfluous hair Removal with the monopolar diathermy needle Arch Dermat & Syph 46 496 1942

Firestone C Cosmetic reduction of full everted lower lip Northwest Med 45 499 1946

Gillies H D Plastic Surgery of the Face Oxford Med Pub 1920

Gordon S Autograft of amputated thumb *Lancet Dec 23 1944 p 823*

Hance G Brown J B Byars L T and McDowell F Color matching of skin grafts and flaps with permanent pigment injection Surg Gynec & Obst 79 624 1944

*Ivy R H The repair of bony and contour de*formities of the face Surgery 15 56 74 1944

Kessler H H Amputations and prosthesis Am J Surg (N S) 63 560 1944

Lexer, E Weiderherstellungs Chirurgie Leipzig Verlag Von Johann Ambrosius Barth, 1920, p 360

McNichol, J W, and Roger A T An original method of correction of hyperplastic asymmetry of the mandible, Plast & Reconstruct Surg 1 288 1946

New G B, and Erich, J B The surgical correction of mandibular prognathism, Am J Surg (NS) 53 2-12 1941

Pick J F Ten years of plastic surgery in a penal institution J Internat Coll Surgeons 11 315 319 1948

Pickrell K L Tattooing of corneal scars with insoluble pigments, Plast & Reconstruct Surg 2 44 59, 1947

Safian, J Ivory used in reconstruction of receding chin New York State J Med Oct 15, 1938, p 1331

Schuessler, W W, and Filmer, G A A method of restoration of the cilia of the eyelids, Plast & Reconstruct Surg 2 345 347, 1947

Smith, F Some refinements in reconstructive surgery of the face, J A M A 120 352, 1942

Straith C E Possibilities of Plastic Surgery, Clinical Med, 51 309, 1944

Young F Vascular birthmarks, J Pediat 14 671, 1939